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ATLAS OF PECULIAR GALAXIES

HALTON ARP

MOUNT WILSON AND PALOMAR OBSERVATORIES

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PREFACE

Forty years after the discovery that galaxies were independent stellar systems, we still have not penetrated very far into the mystery of how they maintain themselves or what physical forces are responsible for shaping their observed forms. The galaxies are the constituent units of mass and energy in the universe, and yet we are still challenged by such questions as: What causes the characteristic shape of spiral galaxies? How are elliptical galaxies related to spiral? How are galaxies formed, and how do they evolve?

It is difficult to resist an oversimplified impression of what a galaxy is because the Hubble classification divides the galaxies into the well-known categories of smooth, amorphous ellipticals and flattened spirals with star-studded arms. But not all galaxies fit the schematic idealization of the Hubble sequence of nebular forms. In fact, when looked at closely enough, every galaxy is peculiar. Appreciation of these peculiarities is important in order to build a realistic picture of what galaxies are really like.

But the peculiarities are also important for another reason. If we could analyze a galaxy in the laboratory, we would deform it, shock it, probe it in order to discover its properties. The peculiarities of the galaxies pictured in this Atlas represent perturbations, deformations, and interactions which should enable us to analyze the nature of the real galaxies which we observe and which are too remote to experiment on directly. In general, the more conspicuous the peculiarity, the more illustrative it is of special events and reactions that occur in galaxies. Therefore the greatest deviations from the normal are emphasized in this Atlas. In some cases small peculiarities are included to illustrate, in sequence, how a certain type of peculiarity develops in importance until it dominates the form of the object. But it is from this overall range of experiments that we must then select and study the ones which will give the most insight into the composition and structure of a galaxy and the forces that govern it.

The present Atlas specifically started from an attempt to better understand spiral galaxies. Many analyses, often complex mathematical treatments have been made over the years, starting from the assumption that spiral arms were the result of tracks of stellar orbits moving under the gravitational influence of a central force field. I believe that the forms of spiral arms, their bifurcations and convolutions cannot be explained by such theories. In 1962 I undertook to assemble a series of photographs that would demonstrate this point. In the investigation of these spiral properties, galaxies which showed unusual or perturbed arms or filamentary extensions were sampled with high-resolution photographs with the Palomar 200-inch telescope. Subjects were first drawn from the pioneering work on peculiar galaxies by Zwicky and Vorontsov-Velyaminov. So many important objects emerged under high-resolution, limiting-magnitude study, however, that the investigation into the nature of spiral arms was postponed in order to systematically organize these new phenomena into groups and to publish a representative sample of the most significant objects.

The Atlas as it has been realized in the following pages illustrates again that galaxies contain more than just stars, radiation, and gravitation. The pictures emphasize the importance of dust in some, they particularly imply a much more important role for the gas in general, and point to the existence of either new forces or forces which previously have been little considered. For example, if we consider galaxies to be merely an assemblage of mass particles, we should be able to treat them, in the limit, hydrodynamically as a frictionless fluid. But the twisted, distorted shapes and curious linkages pictured there suggest that viscosity-like forces are present. Dynamical friction does not seem sufficient because some of the filaments suggest a degree of viscosity approaching that of an elastic medium. Probably the only agency likely to account for this is that of magnetic fields that interconnect regions of wholly or partially ionized gas. Vorontsov-Velyaminov has stressed in the past the probable magnetic nature of some of the effects in peculiar galaxies.

Magnetic forces are very difficult to study optically, but are undoubtedly of great importance in our universe. Recent radio astronomy discoveries of violent events in galaxies reveal sources of energetic charged particles. These charged particles interact with magnetic fields and offer the hope of mapping, measuring, and understanding cosmic magnetic fields. The connection between the plasmas observed with the radio telescopes and the optical evidences of plasma effects pictured in the present Atlas is now open to us.

The overall aim of this Atlas is to present a number of examples of various kinds of peculiar galaxies. They are displayed in groupings that appear roughly similar, thereby furnishing also a rough, initial classification. Phenomena which each group represent may then be investigated by selecting the most favorable members in size or brightness, studying different members of the group in different orientations, and, finally, making some preliminary statistics of certain kinds of phenomena and their relationship to other observable parameters. It is hoped that this investigative procedure will not only clarify the workings of galaxies themselves, but reveal physical processes and how they operate in galaxies, and ultimately furnish a better understanding of the workings of the universe as a whole.

It is a pleasure to acknowledge the help of William Miller who photographically copied the original glass negatives, Lowell Peterson of Graphic Arts at the California Institute of Technology who supervised the large-size photographic reproduction of the Atlas, Frank Brueckel who carried out many computational tasks connected with the Atlas, and, of course, all those astronomers who suggested candidates for the Atlas from their own personal store of knowledge and who gave advice and encouragement.

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INTRODUCTION

The National Geographic Society-Palomar Sky Survey was completed in 1956. For seven years the 48-inch Schmidt telescope had surveyed the sky north of $\delta = -27^\circ$. The 1758 highest-quality plates that were finally accepted penetrated about three times deeper into space than any previous survey had ever reached. Astronomers are still studying and cataloguing the information contained in this survey, and will continue to do so for many years to come. One of the first astronomers to use the prints of the Sky Survey for a systematic study was Professor Vorontsov-Velyaminov of the Sternberg Astronomical Institute in Moscow (2). In 1959 he published positions, with copies of Sky Survey pictures, of 355 peculiar and interacting galaxies that he had discovered on those prints. The publication of this list enabled the undertaking of one kind of project for which the 48- and 200-inch telescopes on Palomar Mountain were originally designed. The fast-focal-ratio, wide-field Schmidt telescope was intended to survey objects of interest. The maximum light-gathering power and resolution of the 200-inch could then be turned individually on the most interesting objects.

When selected members of Vorontsov-Velyaminov's catalogue were photographed with the 200-inch, some turned out to be much more interesting than on the smaller-scale plates, while others turned out to be less interesting or ordinary. After some preliminary experience with the 200-inch scale, it soon became possible to inspect the Vorontsov-Velyaminov objects first on the Survey prints to cull out the less interesting objects. In the process of inspecting these objects and checking their positions, other very unusual galaxies were noticed on the same Survey prints and included in the 200-inch program. This demonstrated that not all the important objects had been catalogued, and efforts were made to compile from other sources a more complete list of candidates for peculiar galaxies. One additional source of peculiar-galaxy candidates was the set of notes which A.G. Wilson had made upon inspecting the original Sky Survey plates as they were taken. These were kindly put at my disposal. Another list of peculiar objects was given me by E. Herzog, who has carefully searched the Survey plates for such objects. Thornton Page contributed peculiar objects he knew and a list of peculiar galaxies which C.A. Wirtanen had compiled from the Lick Position Survey. Holmberg's pairs of galaxies were inspected. Special objects were also contributed by W.W. Morgan, F. Zwicky, Charles Kowal, and Gibson Reaves. Finally, the plates of Minkowski and Baade, which are stored at the Mount Wilson Observatory, were searched for peculiar objects. None of these lists, including my own, had very much overlap with each other. The conclusion seems to be that, aside from the brighter and therefore well-known peculiar galaxies, the fainter peculiars have not been fully catalogued, and that the fainter peculiar galaxies pictured in this Atlas represent only a sample of that group.

At first the photographs with the 200-inch were made with various plate and filter combinations to discover in which wavelengths the peculiar features would show best. Although red wavelengths

sometimes showed features better, in general, the filaments, connections, and faint outer features were more conspicuous on blue-sensitive (Eastman Kodak 103a-O) plates. At that time, however, the sky was becoming so dark because of sunspot minimum, that it was possible to reach fainter limiting magnitudes by exposing blue plates for sixty to seventy minutes. To make the project possible in terms of available observing time, the band-pass was widened by using 103a-D plates and including the visual as well as blue wavelengths in a limiting exposure of the order of thirty minutes. Finally, it became clear that the night sky emission line at $\lambda 5577$ was contributing appreciably to the brightness of the night sky background, and the emulsion was changed to 103a-J from there until the conclusion of the project. The 103a-J plates registered light roughly between the $\lambda 3600$ half-transmission point of the f/3.67 corrector lens of the 200-inch telescope and the $\lambda 5400$ photographic emulsion cutoff. That, in general, is the region of maximum contrast for galaxies (10), and the very deep exposures made here (to densities of 0.7 to 1.2 for sky background), the very dark night skies, and the 20 percent increases in development time give, on the average, a set of photographs that show fainter stars - and particularly fainter surface brightness features - than previously detected in galaxy subjects. The reproduction of these prints in the Mount Wilson and Palomar photographic laboratory by William Miller was a difficult job which was carefully controlled so that almost all the original features on the plates, even the faintest, are reproduced in the Atlas.

Whenever possible, poor-seeing plates were repeated under better seeing conditions, so that the final Atlas contains only plates taken with seeing 2 or better. The star images on the plates taken with the 200-inch presented in this Atlas are therefore generally between 1" and 2" diameter. Search of the Observatory plate records located some of the prospective Atlas galaxies which had been already photographed. I am grateful to Zwicky, Sandage, and Baum for allowing me to reproduce some of the photographs of these objects, and they are credited under the listed plate numbers in Table 1. Most of the 338 photographs shown in the Atlas are from plates taken with the 200-inch telescope. Occasionally a very large object is shown in a print from a 48-inch telescope plate (designated PS) in order to emphasize its correct sequence in the order of forms.

Because so many of the physical processes pictured are not understood, no rigorous attempt at classification has been made. The galaxies have been grouped empirically, putting together all the objects that look alike. Special emphasis is on the form of the galaxies or the nature of the peculiarity and the gradual change of the peculiarity from object to object. Sometimes an object will belong in more than one category, and then it is cross-referenced in Table 1 or shown under different magnification in different sections of the Atlas. The schematic plan of arrangement of the different kinds of galaxies is shown in Diagram 1. The largest class involved peculiar spiral galaxies (Nos. 1 - 102). The largest subclass of peculiar spirals are spirals with companions attached to spiral arms (Nos. 102-145). Of course, there is overlap, and in the very interesting group ranging from Nos. 91-114 it is impossible to say whether the E is attached to the spiral galaxy or vice versa. The third major group (Nos. 146-268) involves galaxies or groups of objects that are not primarily classifiable as either E's or spirals, or whose most outstanding peculiarity does not fall in the first two major categories. In the fourth major category (Nos. 269-327), group character is the most important consideration. Six objects classifiable only as miscellaneous are shown at the end (Nos. 332-338).

When possible, information has been referenced in the literature regarding magnitude, redshift velocities, and any known spectral peculiarities. Table 2 lists all the objects in this Atlas in order of right ascension and gives known redshift velocities. In Table 3 coincidences of Atlas objects with catalogued radio sources are noted and referenced. With the exception of bright radio sources such as Fornax A, Atlas objects were not selected because they were radio sources although Minkowski's plates were generally taken in search of radio source identifications. In many cases, however, nothing more is known about an object than what is shown in the Atlas. An important task in the future will be to undertake photometric and spectroscopic observations of these objects. Then, when distances, absolute magnitudes, and spectral characteristics are known, a more meaningful classification and interpretation of the objects in this Atlas can take place.

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THE ATLAS AND THE CATALOGUE

The 338 photographs shown in the following fifty-seven pages of the Atlas all have a notch marking north. West is 90° clockwise. The prints represent magnifications from the original plates of 1x, 2x, 4x, 6x, and 10x. Since all the 200-inch plates in this program were taken with the Ross f/3.67 corrector lens, the original plate scale is 11".1 / mm. The scales on the Atlas prints therefore vary from 11" / mm to 1'.1 / mm. The natural scale (1x) of the few prints from Schmidt plates is 67" / mm. In reproduction of the large-size photographic edition, all these scales have been reduced by a factor of 0.97.

About one-third of the prints were made by an automatic (fluorescent screen) dodging process, i.e., by compressing the density range so that one can see very faint features and yet see into the brighter inner regions on the same print. In some cases the automatic dodging has introduced slightly lighter halos around the stars.

THE CATALOGUE

- Col. 1: Identification number in this catalogue. See Diagram 1 for arrangement of types of objects.
- Cols. 2-3: Right ascension and declination of objects for 1970 epoch. Positions are from three sources: (1) NGC positions where available. If more than one NGC object is pictured, the position of the westernmost (smallest number) is given. (2) Positions from 200-inch dial readings calibrated by objects with known positions. (3) Measurements on 48-inch Sky Survey plates (whenever possible, differential measurements from nearby NGC objects). The final accuracy of these positions, from cross-checking the different methods, is on the average better than $\pm 0.^m2$ in R.A. and $\pm 2'$ in Dec. A few positions are from Vorontsov-Velyaminov.
- Col. 4: Designation. NGC or IC numbers are given when object has one, otherwise designation is blank.
- Col. 5: Plate number. PH designates 200-inch Hale telescope; PS designates 48-inch Schmidt. Plates taken by Arp unless designated B = Baade, Bm = Baum, M = Minkowski, S = Sandage, Z = Zwicky.
- Col. 6: Exposure in minutes.
- Col. 7: Kind of emulsion used - 'bk' designates baked and 'lb' designates lightly baked; 'exp' designates experimental.
- Col. 8: Identifies the filter used, if any.

Col. 9: Seeing.

Col. 10: Magnification (usually varies from 1x to 10x) in which 1x = 11" / mm. Asterisk denotes 48-inch Schmidt scale in which 1x = 67" / mm.

Col. 11: Source. As far as can be determined, the person who first noticed the peculiar object is named. Vorontsov-Velyaminov (VV) numbers are given when they exist. DDO is David Dunlap Observatory.

Col. 12: Remarks on objects shown in photographs. Major peculiarities are described in Diagram 1; additional peculiarities and remarks are noted here.

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- [There is no reference (42).]

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No.	α (1970)		δ (1970)		Designation	Emul.	Filter	Seeing	Source
	h	m	$^{\circ}$	'					
1	9	22.9	+49	28	NGC 2857	103a-J	-	2	
2	16	15.1	+47	7		103a-Olb	GG 13	3	DDO 204
3	22	34.8	-3	6		103a-Olb	GG 13	3	DDO 214
4	1	47.0	-12	31		103a-Olb	GG 13	4	DDO 14
5	11	22.7	+3	29	NGC 3664	103a-D	-	3	DDO 95, VV 251
6	8	11.1	+46	5	NGC 2537	103a-D	-	3	VV138
7	8	49.1	-16	30		103a-D	-	3	VV28
8	1	20.9	-1	1	NGC 497	103a-D	-	2	
9	8	11.6	+73	42	NGC 2523	103a-J	-	2	
10	2	16.6	+5	30		103a-D	-	3	Wilson 13
11	1	7.9	+14	11		103a-D	-	3	VV348
12	8	33.4	+28	41	NGC 2608	103a-O	-	1-2	
13	22	58.6	+15	49	NGC 7448	103a-Olb	GG 13	4	
14	22	34.1	-26	12	NGC 7314	103a-Olb	GG 13	3	
15	22	50.0	-5	43	NGC 7393	103a-Dlb	-	4	VV68
16	11	18.6	+13	11	NGC 3627	103a-D	GG 11	2-3	
17	7	41.3	+73	52		103a-D	-	3	VV349
18	12	4.0	+50	42	NGC 4088	103a-J	-	1-2	
19	0	30.2	-5	19	NGC 145	103a-O	-	1-2	
20	4	18.4	+2	1		103a-O	-	1-2	
21	11	3.2	+30	15		103a-J	-	2	
22	11	58.0	-19	6	NGC 4027	103a-J	-	2	VV66
23	12	40.1	+41	19	NGC 4618	103a-J	-	3	VV73
24	10	52.8	+57	9	NGC 3445	103a-D	-	2	VV14
25	7	17.9	+85	50	NGC 2276	103a-D	GG 11	2	
26	14	2.1	+54	29	NGC 5457	103a-J	Wr.#4	4-3	M101, VV344

27	11	19.4	+53	21	NGC 3631	103a-J	-	3	
28	23	27.1	+22	15	NGC 7678	IIa-O bkd	-	3	
29	20	34.3	+60	2	NGC 6946	103a-O	-	3	
30	17	22.5	+62	11		103a-D	-	3	VV232
31	1	49.4	+21	45		103a-O	-	2	
32	17	12.5	+59	22		103a-D	-	3	VV89
33	13	36.1	+ 6	35		103a-J	-	3	VV6
34	12	40.0	+26	14		103a-J	-	2-3	
35	0	20.7	- 1	34		103a-O	-	3	VV257
36	13	32.9	+31	35		103a-J	-	3	VV4
37	2	41.1	- 0	8	NGC 1068	103a-O	Polaroid	2	
38	17	30.1	+75	45	NGC 6412	103a-O	-	3	
39	3	28.5	-22	22	NGC 1347	103a-D	-	1	VV23
40	13	28.1	+37	34	IC 4271	103a-D	-	3	VV355
41	3	8.4	-20	41	NGC 1232	103a-O	-	3	

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 No. Remarks

- 1 High contrast print of low surface brightness spiral.
- 2 Low surface brightness dwarf. Large bright knot in arm appears almost stellar.
- 3 Low surface brightness dwarf.
- 4 Not known if both galaxies are at the same distance.
- 5 Fainter dwarf 6'S.
- 6
- 7
- 8
- 9 Bifurcated arm does not start at end of bar.
- 10 Nucleus off center in ring.
- 11 Position of larger spiral. Outer arms do not start at termination of bar.
- 12 Nucleus may be double or superposed star.
- 13 High surface brightness.
- 14 Almost no nucleus. (3)
- 15 Feature appears to be a ruptured or obscured ring. Member of group.(18)
- 16 See also 317. Large concentration at end of S arm. (3)
- 17
- 18 End of one spiral arm partially disconnected. (3) (33)
- 19
- 20
- 21
- 22
- 23
- 24
- 25 See also 114. Tubular arm, straight at first, then bent. Secondary arm from straight portion.
- 26 Note straight arms, bright knot on East appears almost stellar. (3)

- 27 Note straight arms, absorption tube crossing from inside to outside of S arm.
 - 28 Note straight heavy arm.
 - 29 Supernova once observed in tip of thick arm. (31)(46)
 - 30 Comp. appears physically connected to flat-on spiral system.
 - 31 High surface brightness irregularity is 5' N.
 - 32
 - 33 Position of larger spiral. See 326 for smaller scale picture. Part of galaxy chain.
 - 34
 - 35 Radio source M00-01 is 50^s W.
 - 36 Knots in arms approach appearance of small companions.
 - 37 Seyfert galaxy. Small knot in arm. (3)(16)(39)
 - 38 Small ring in arm on N side, part of large ring on E side shows in H α only.
 - 39
 - 40 Absorption off edge of small galaxy obscure part of large galaxy. Possible connection.
 - 41 Companion spiral wound in same sense as parent. Note split of companion's arm further into center.
-

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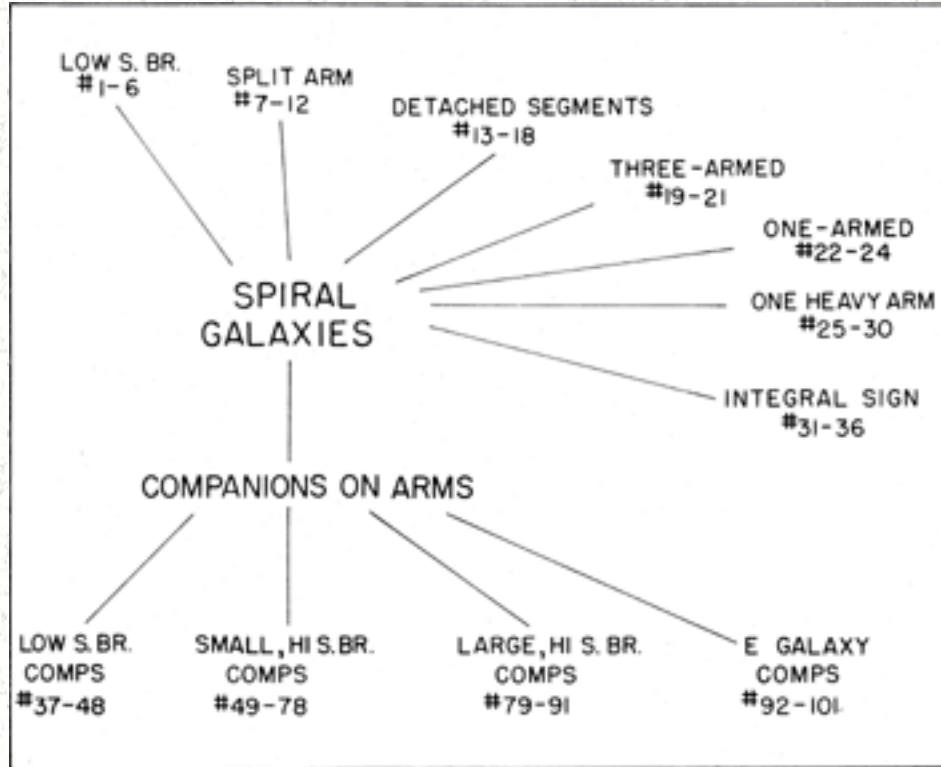
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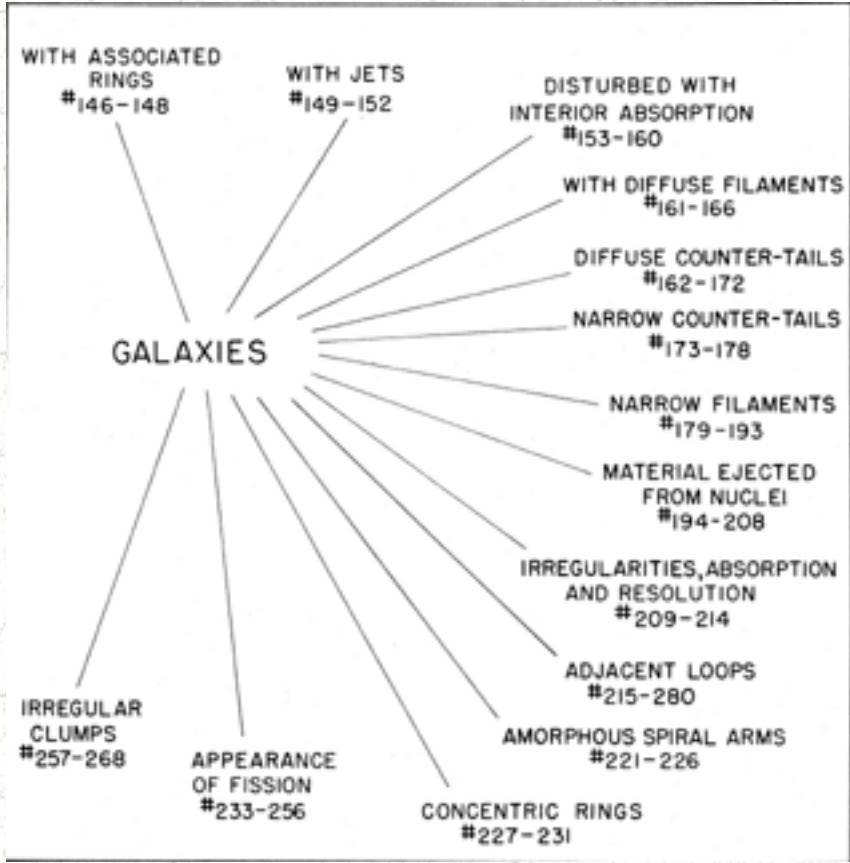
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Figure 1



This is a clickable map.

Figure 2



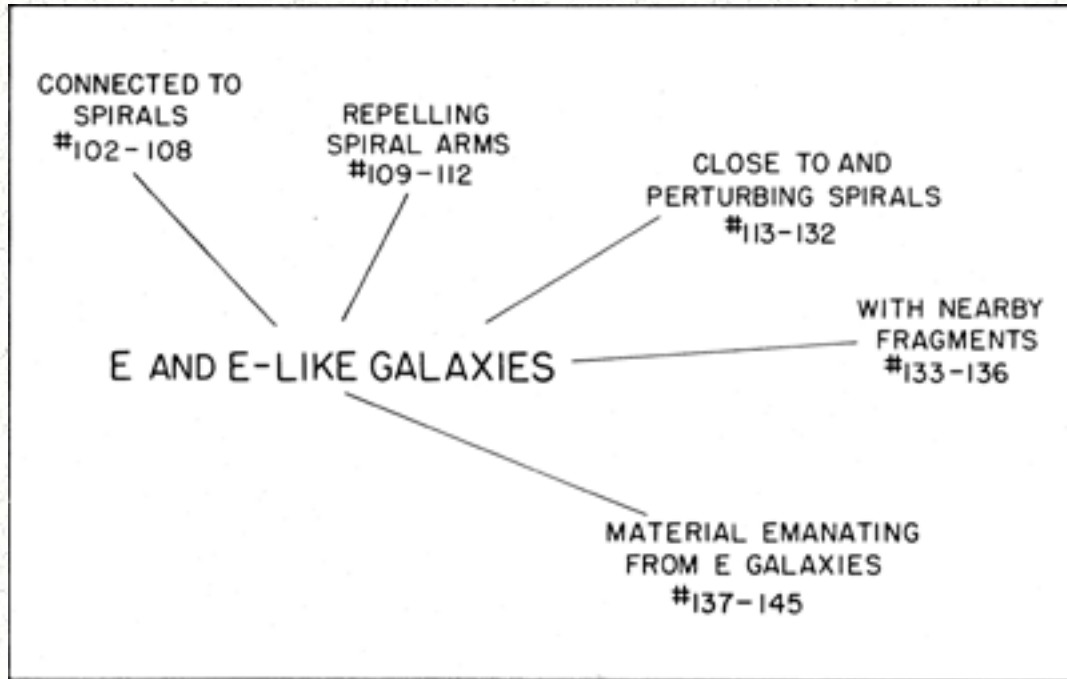
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Figure 3

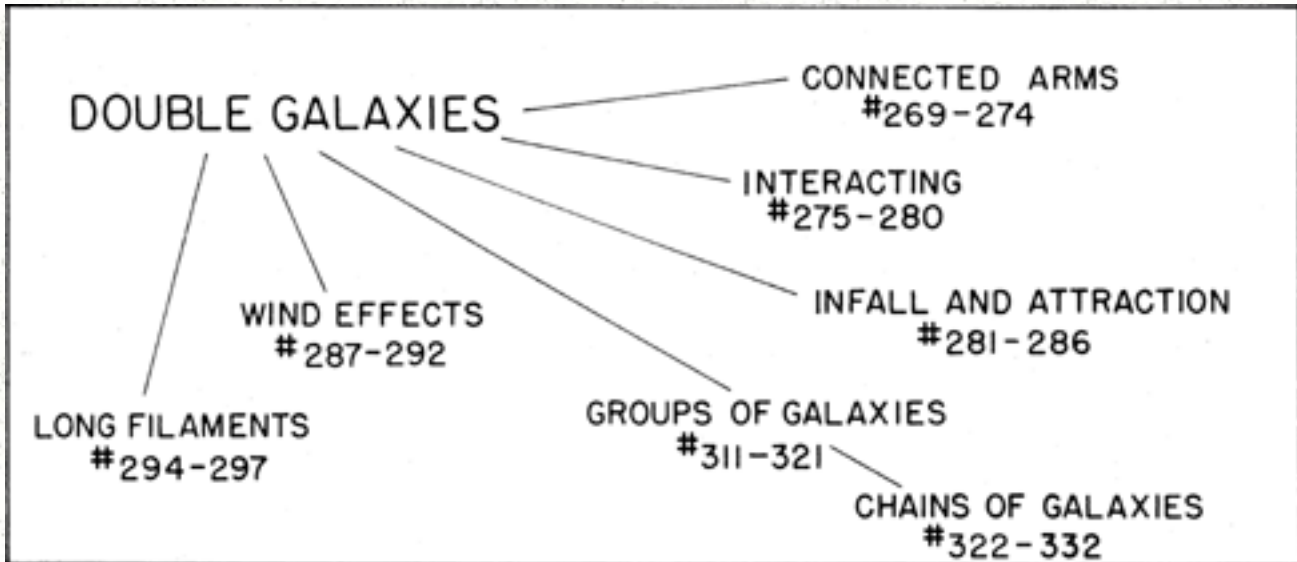


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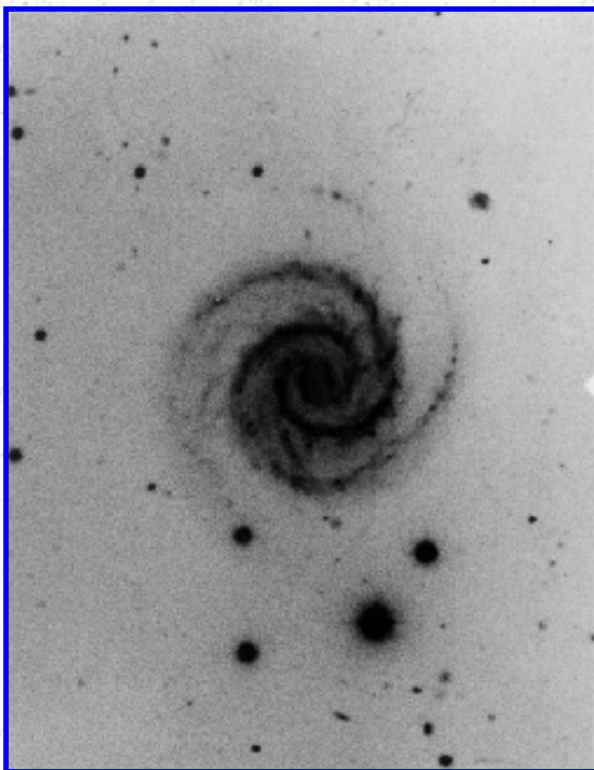
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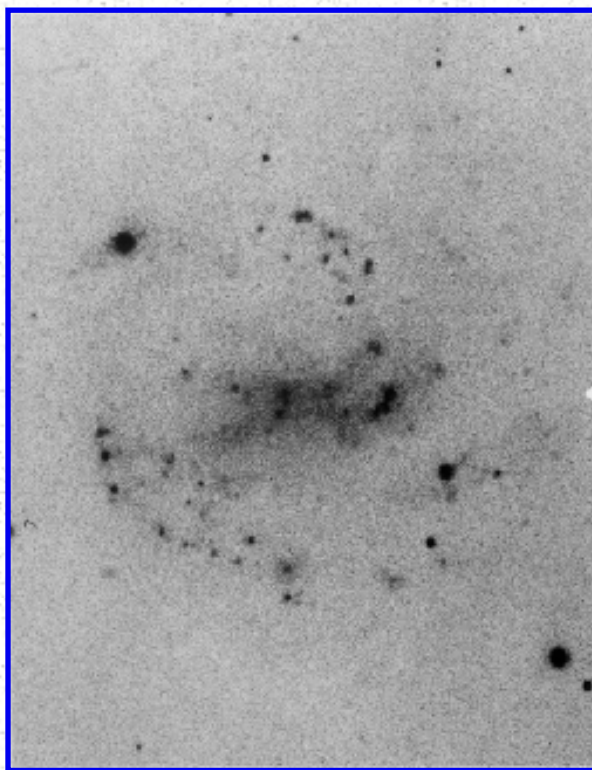
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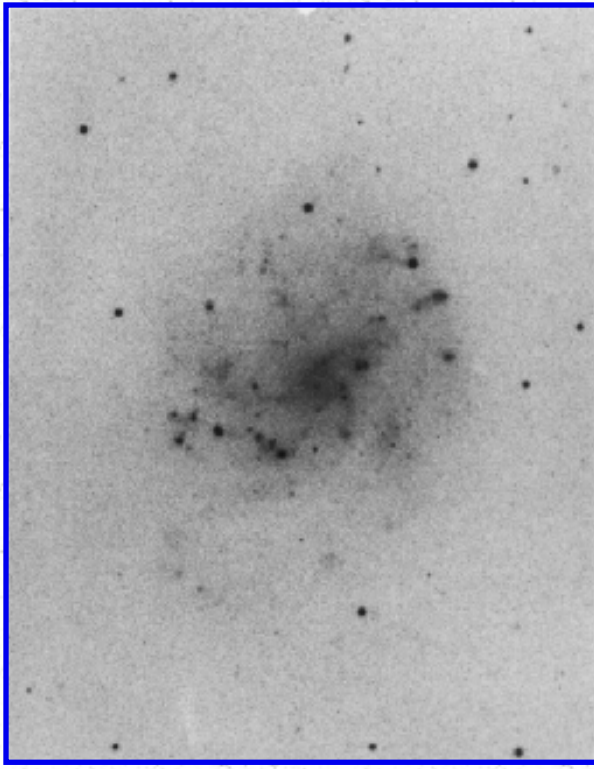
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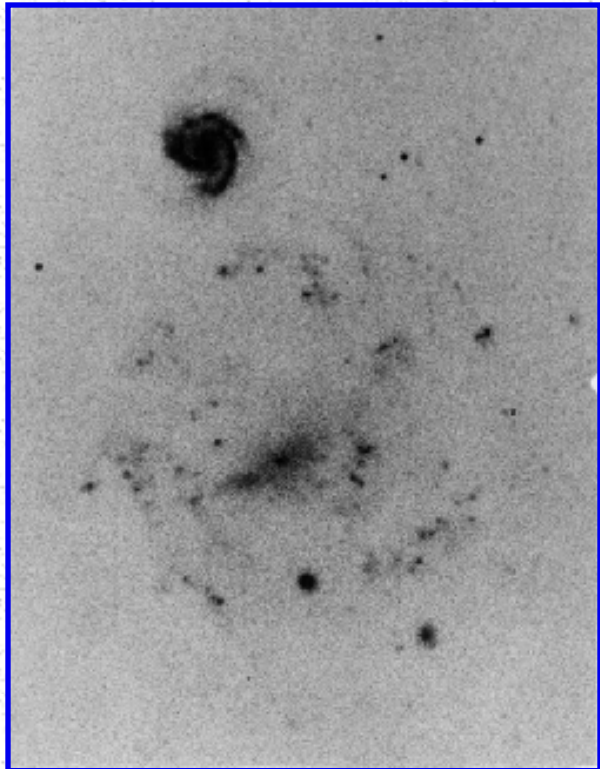
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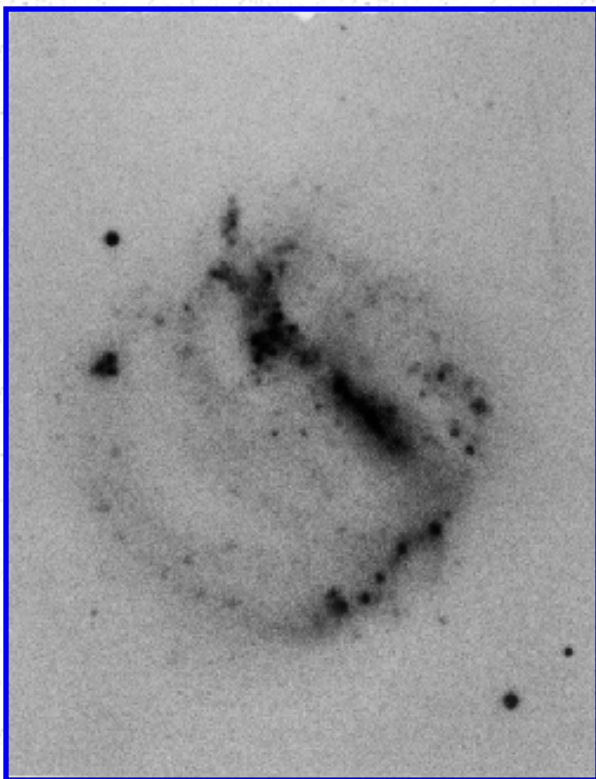
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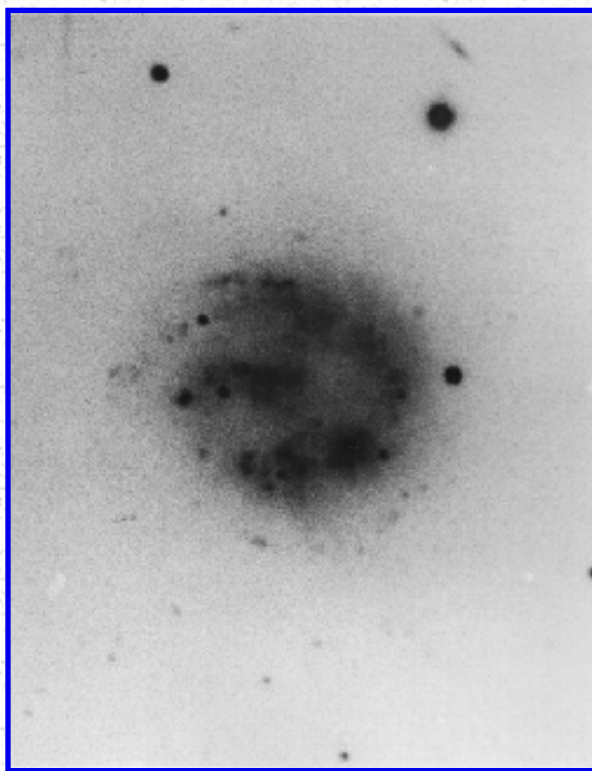
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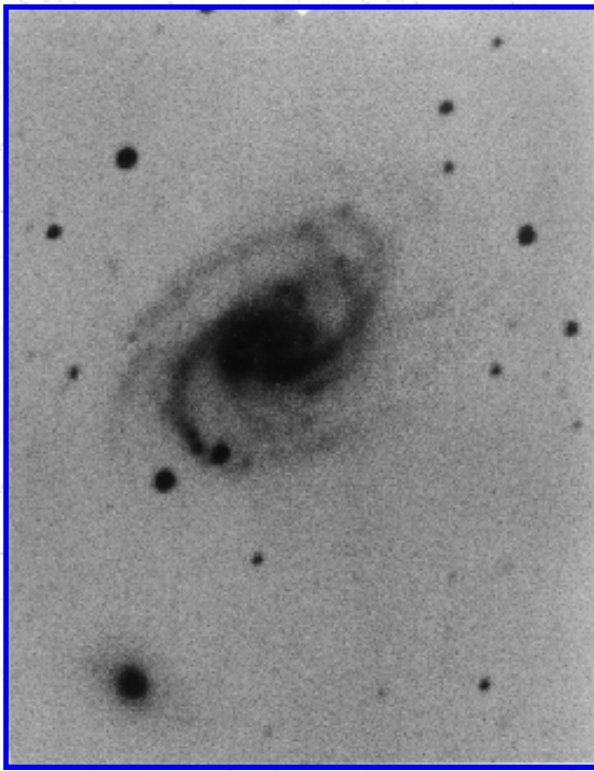
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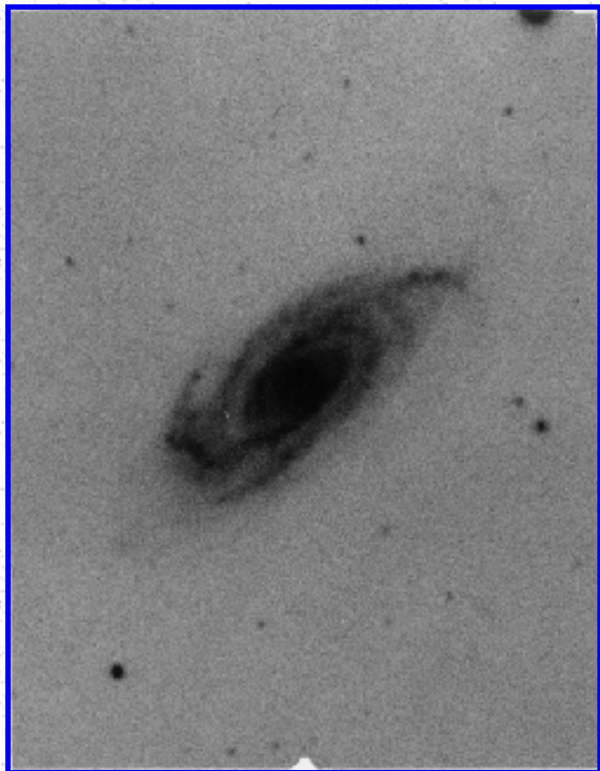
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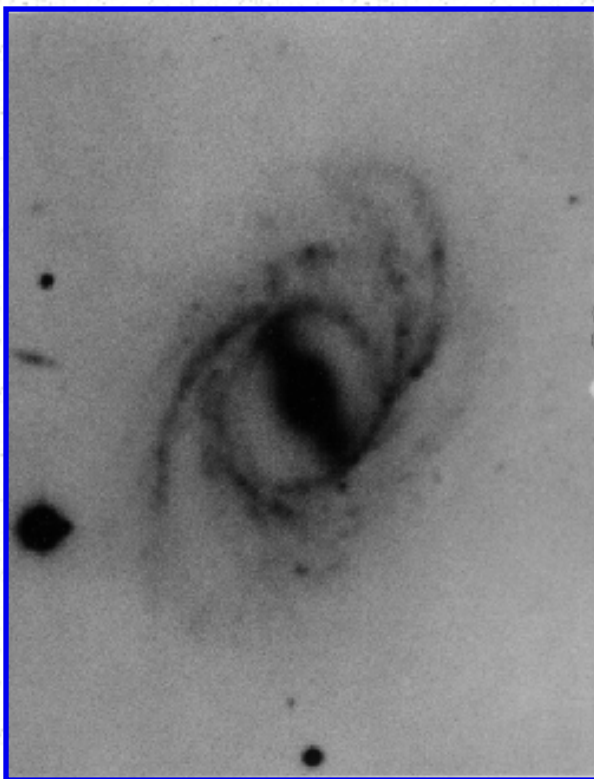
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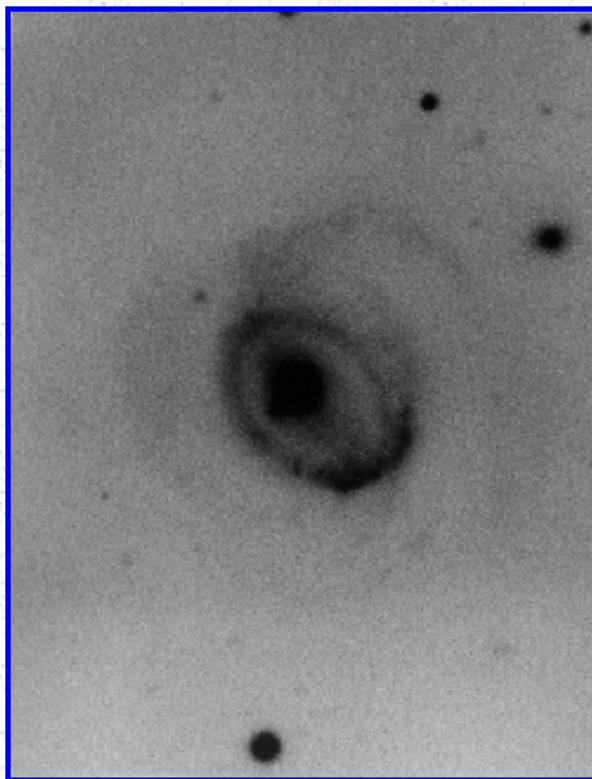
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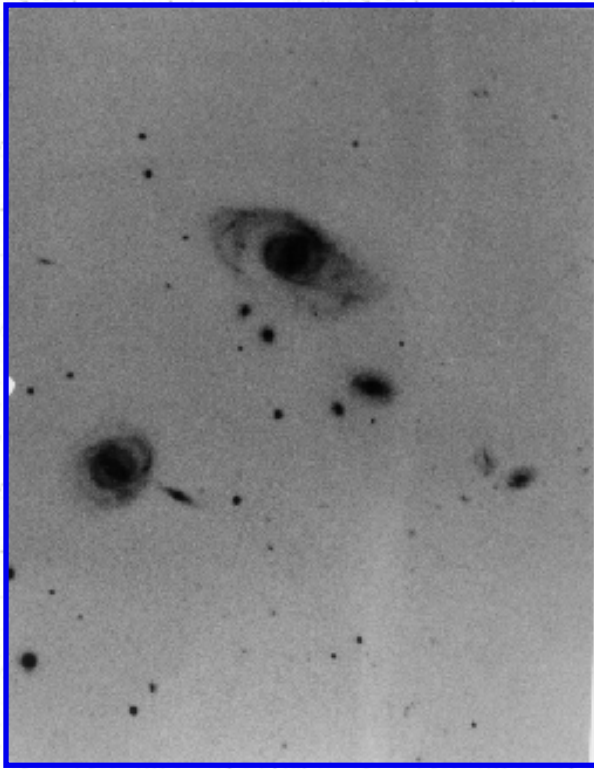
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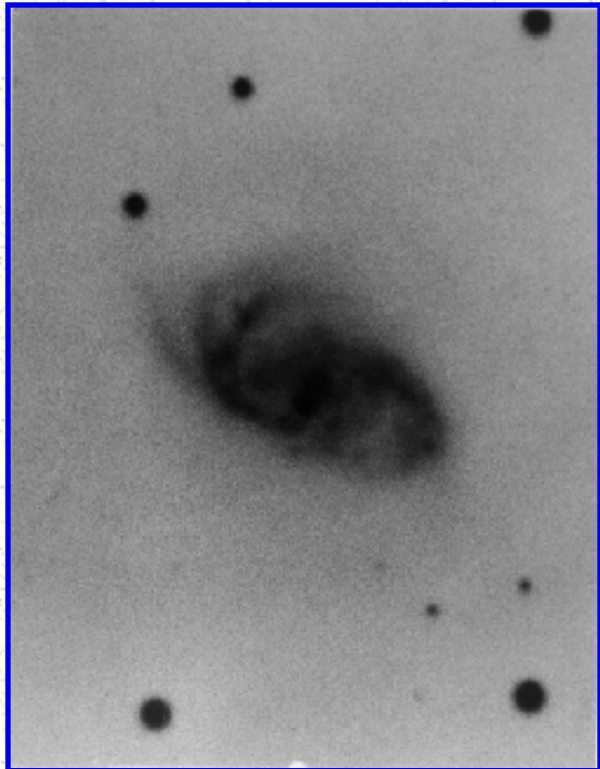
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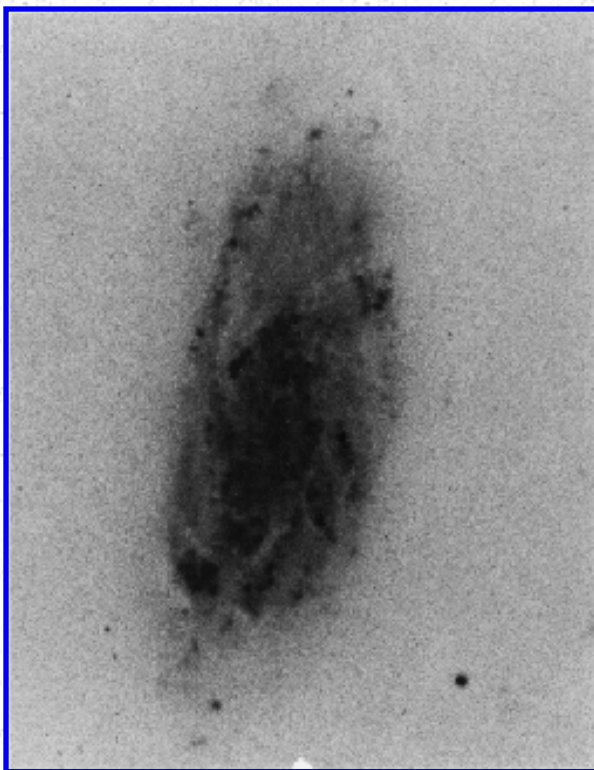
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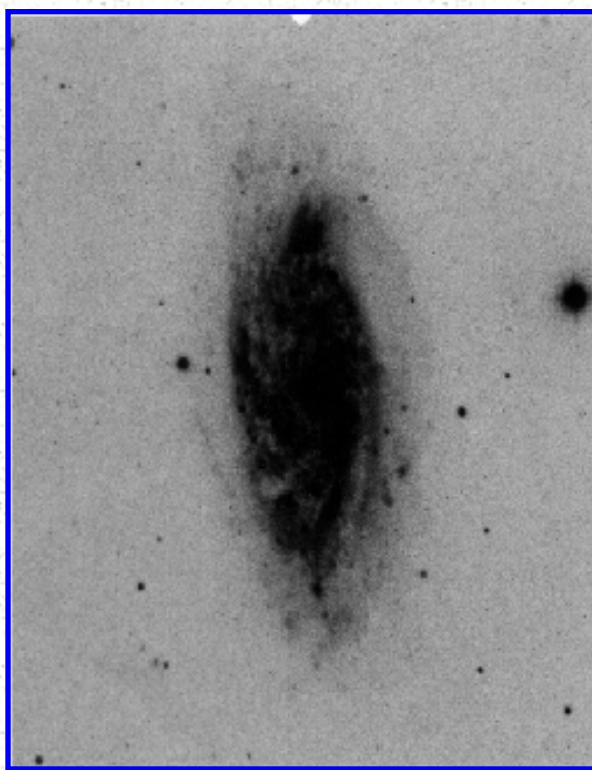
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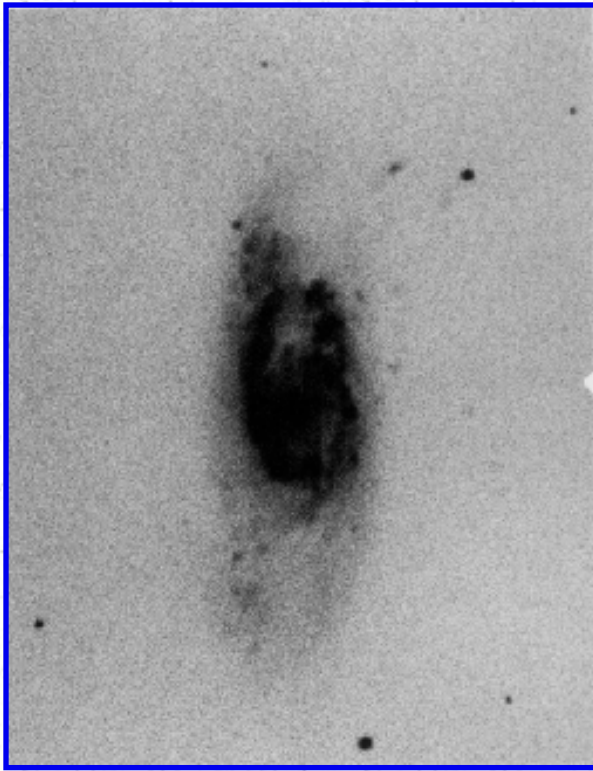
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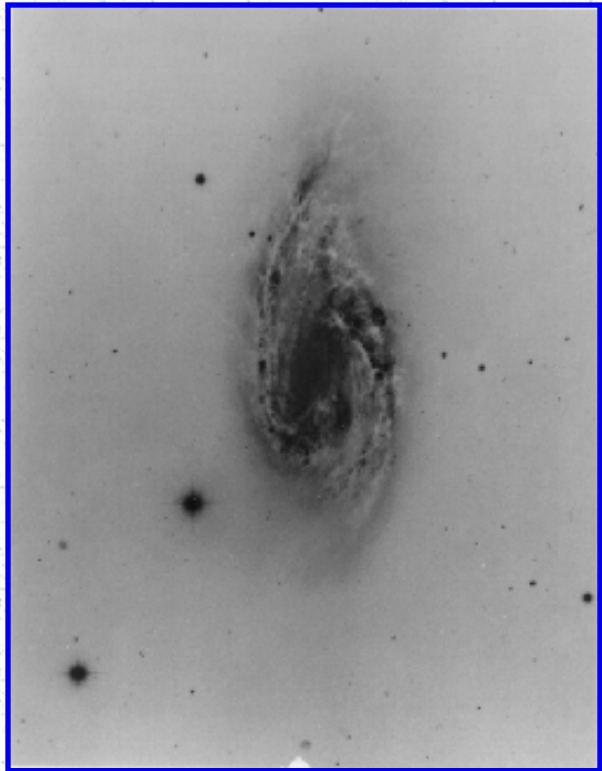
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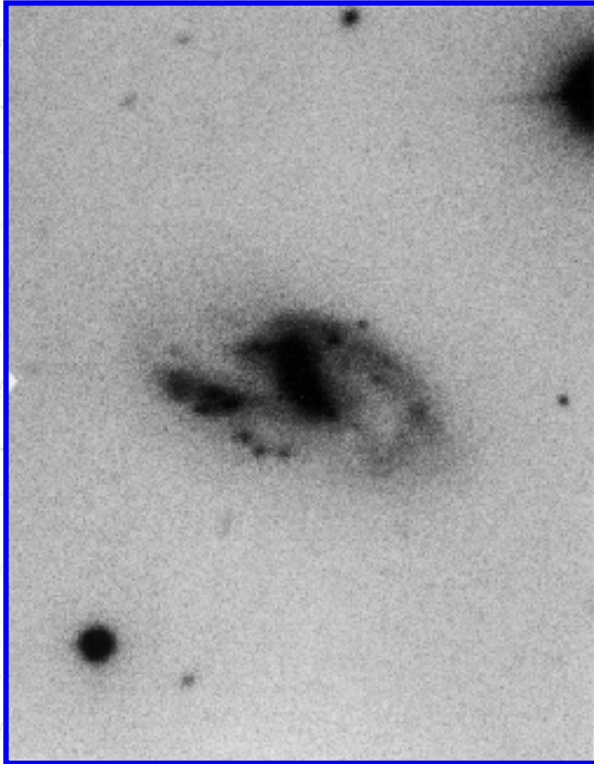
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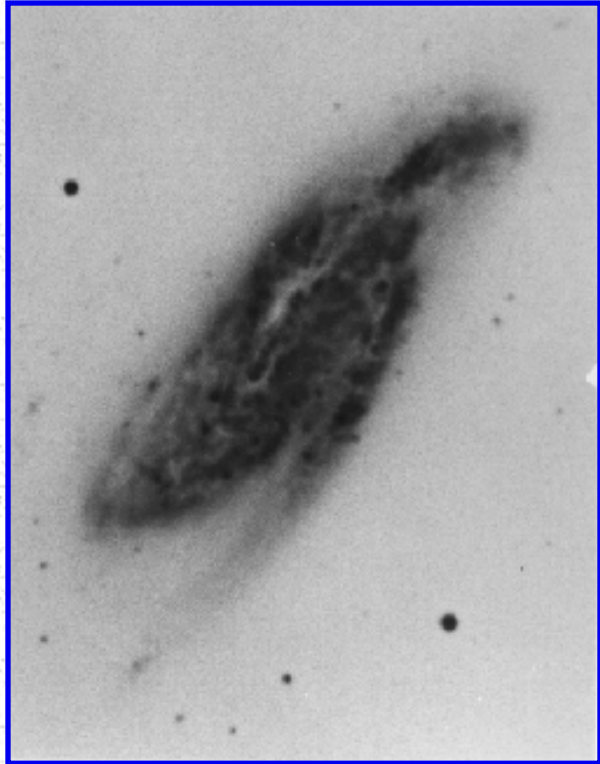
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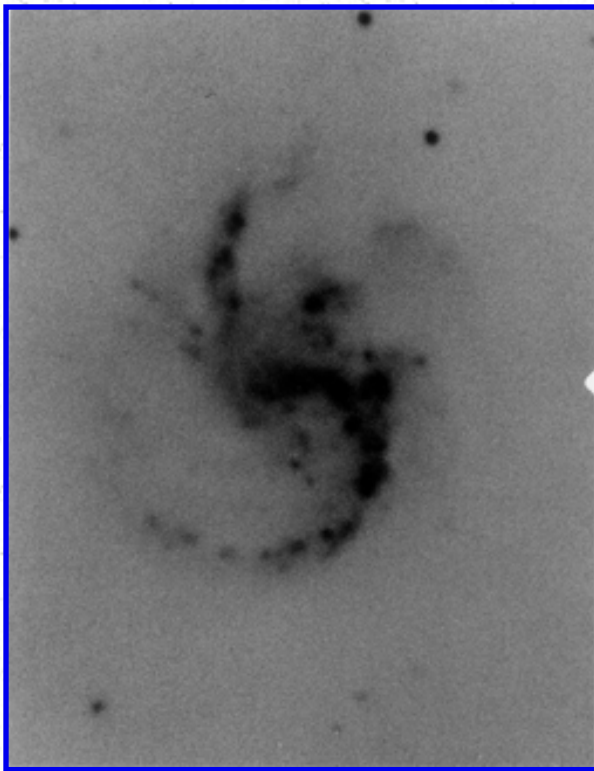
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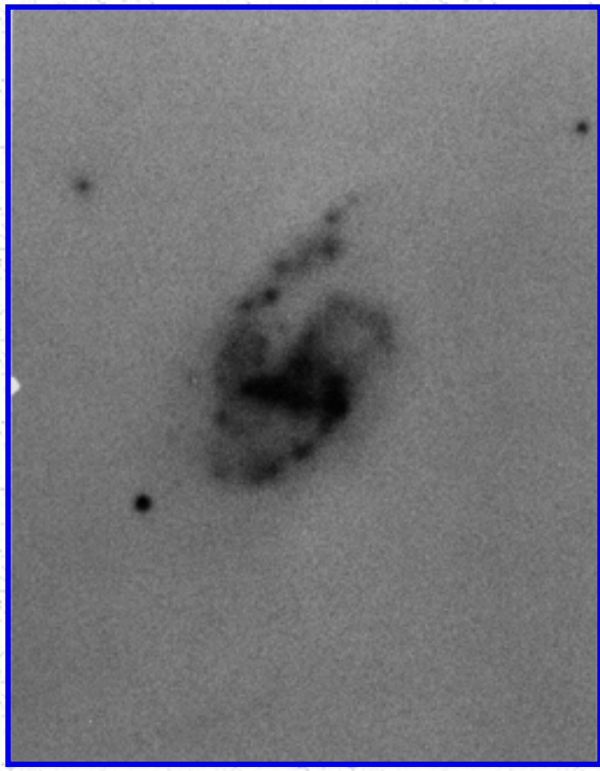
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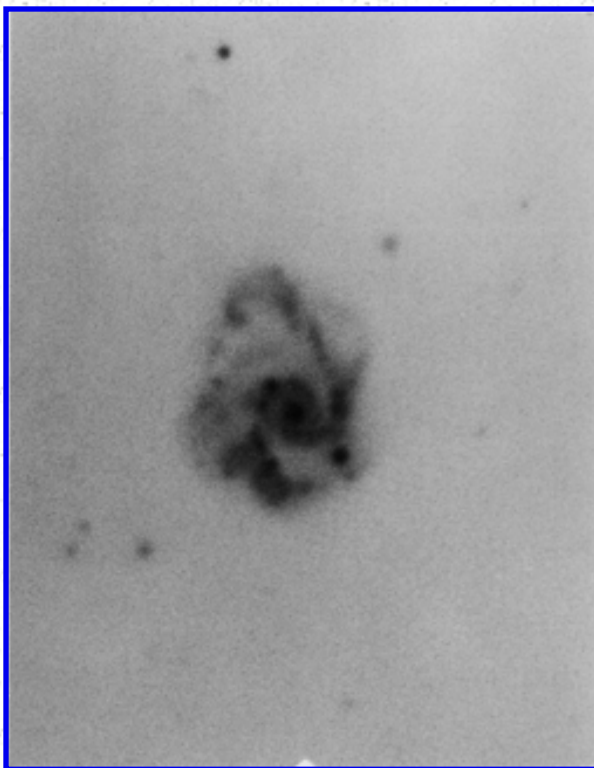
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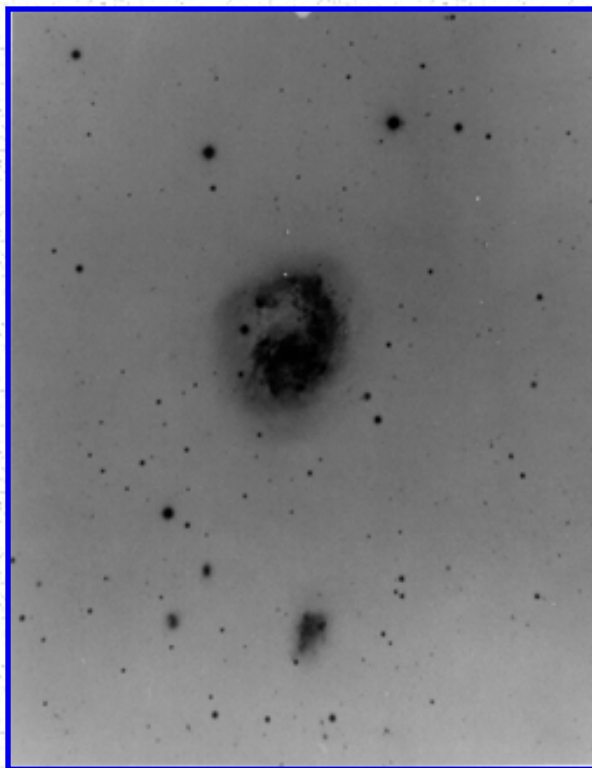
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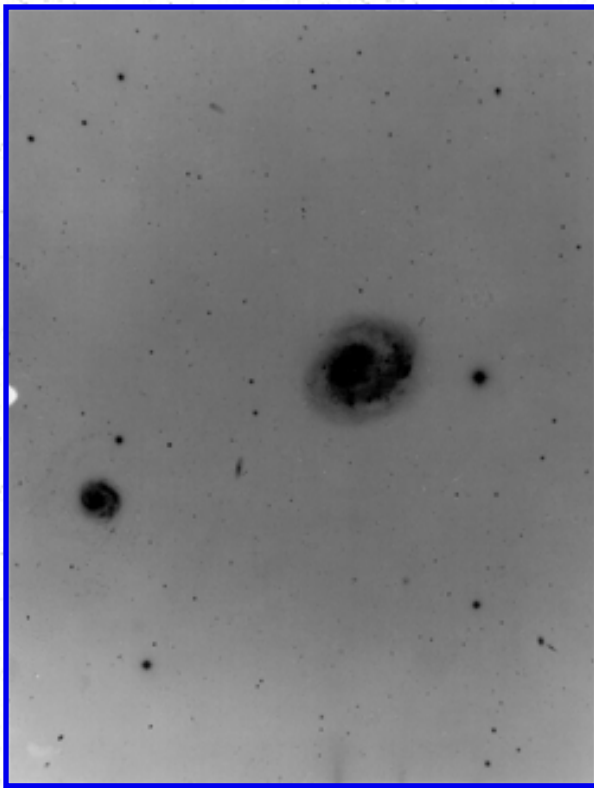
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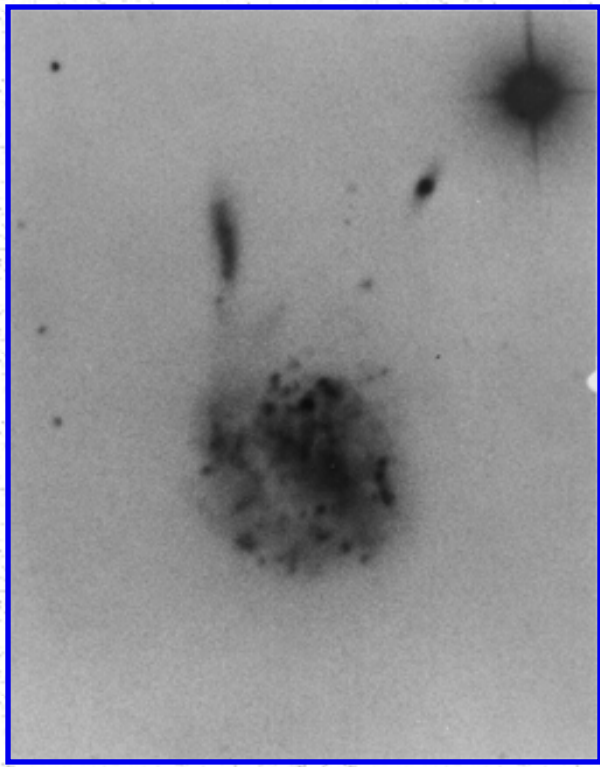
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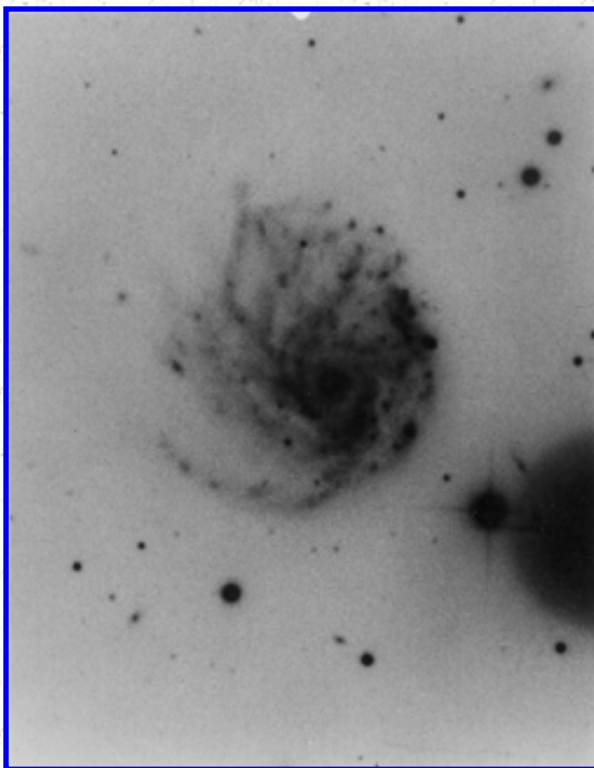
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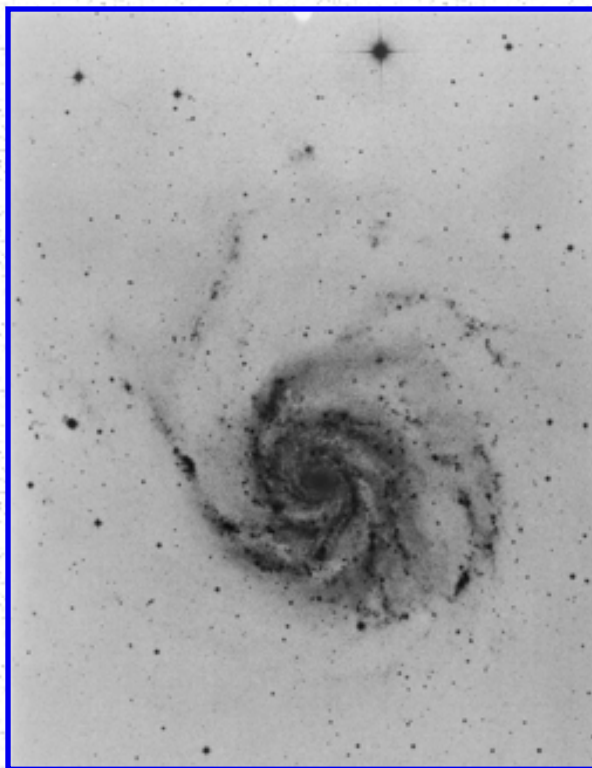
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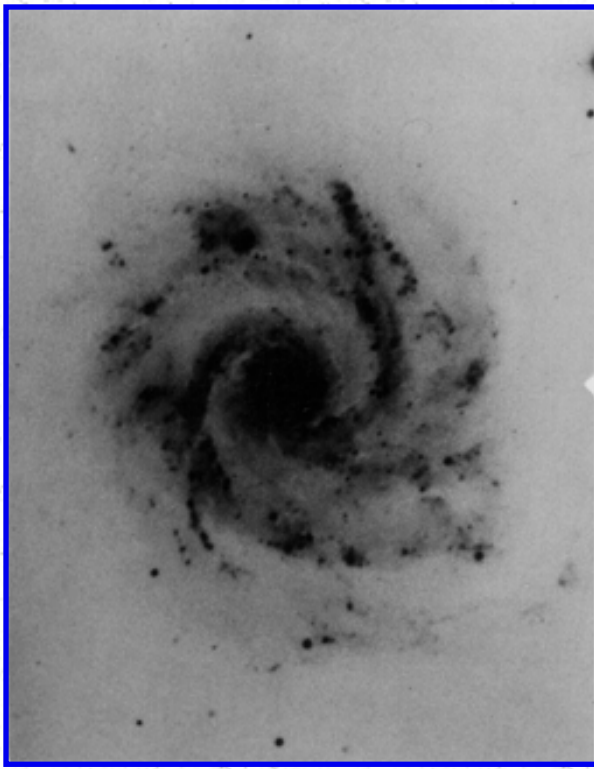
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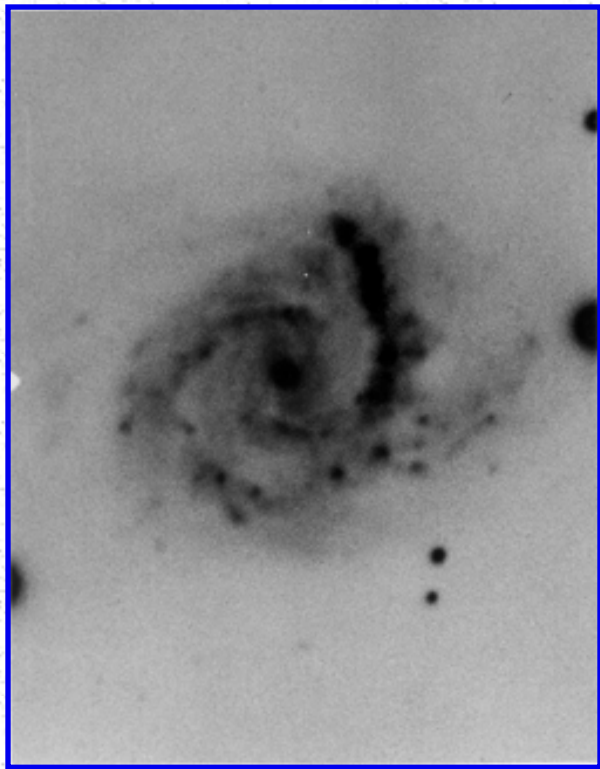
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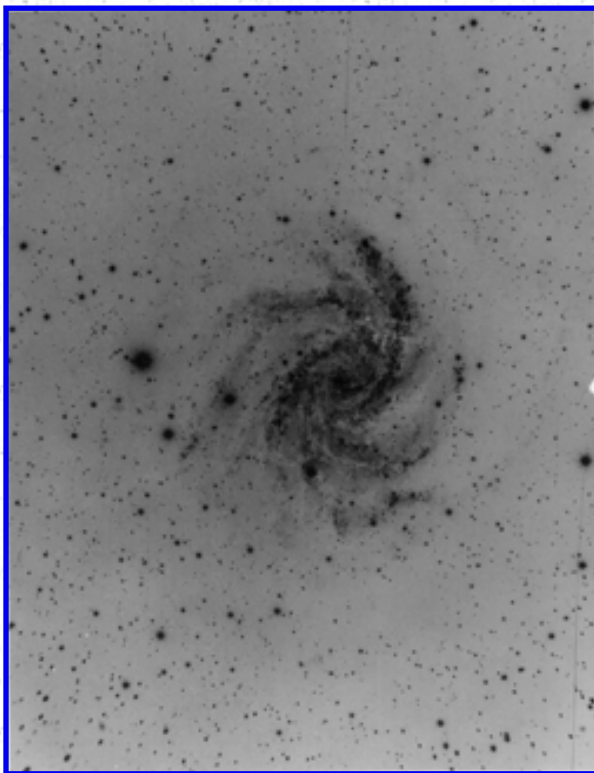
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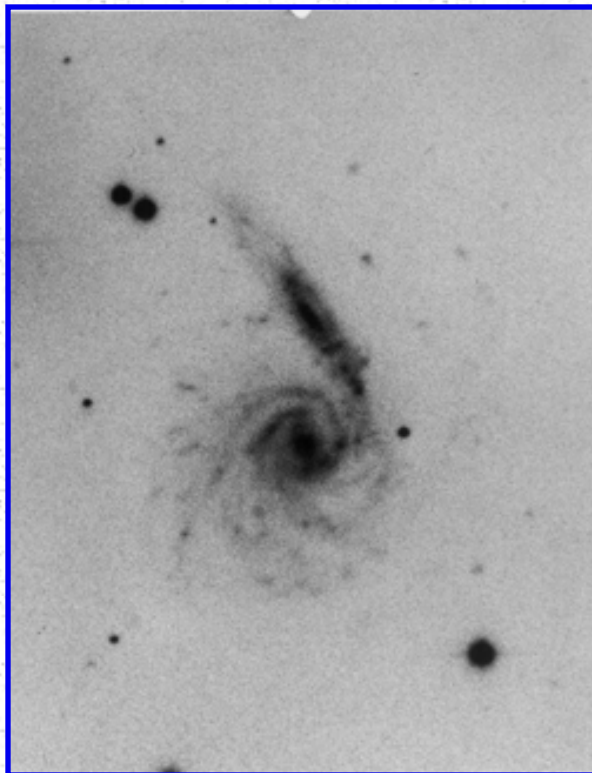
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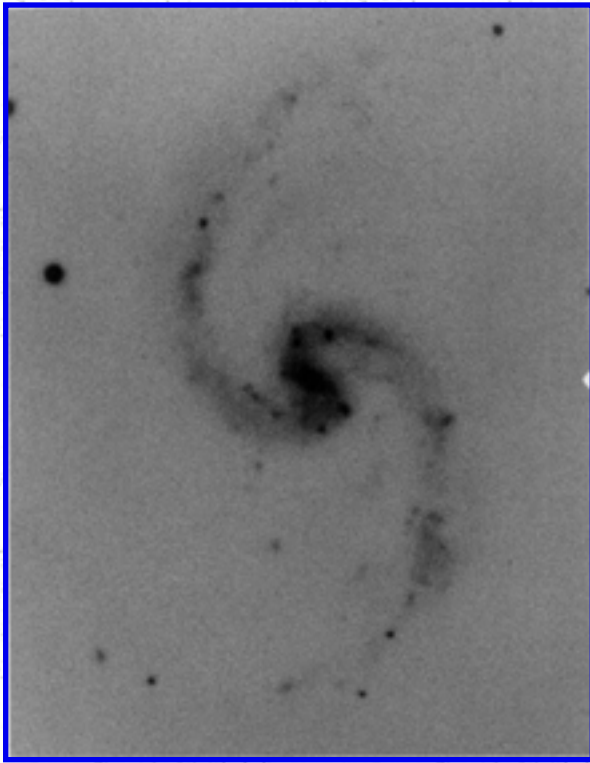
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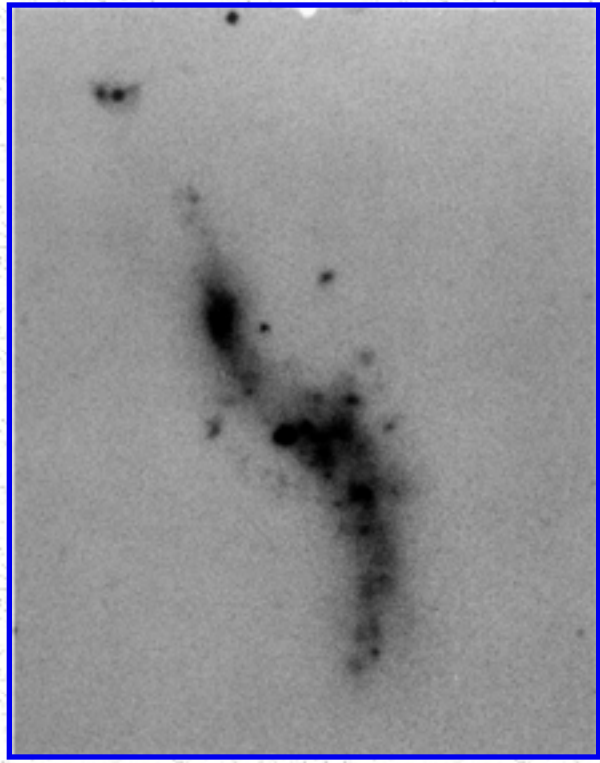
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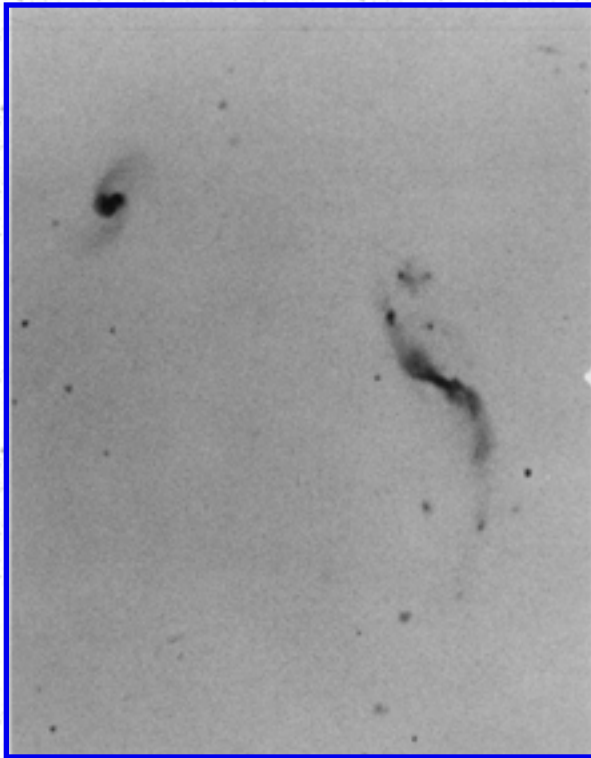
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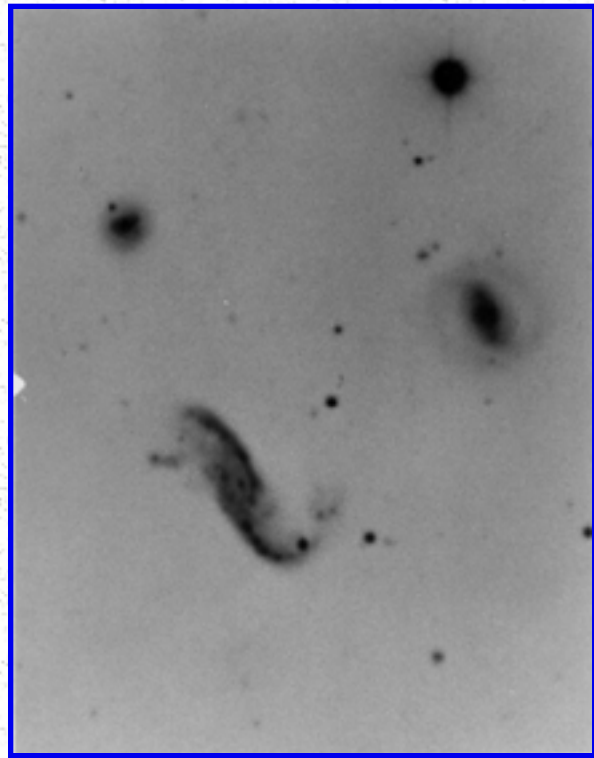
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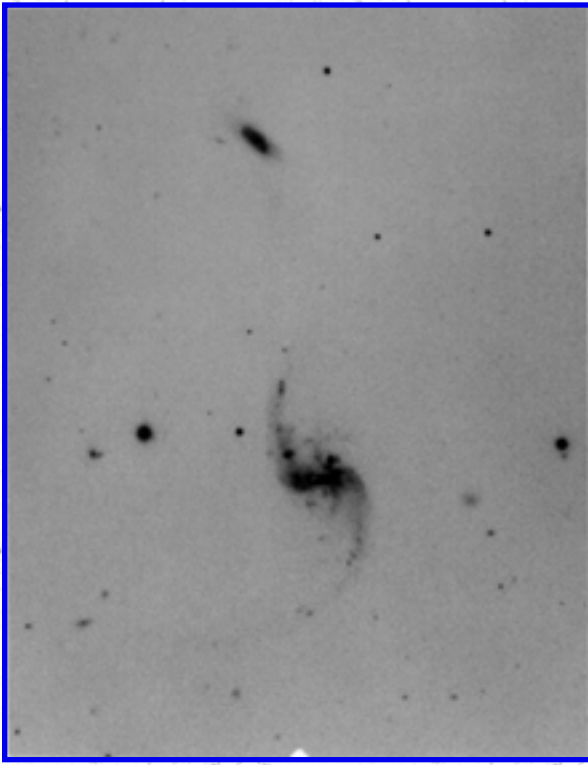
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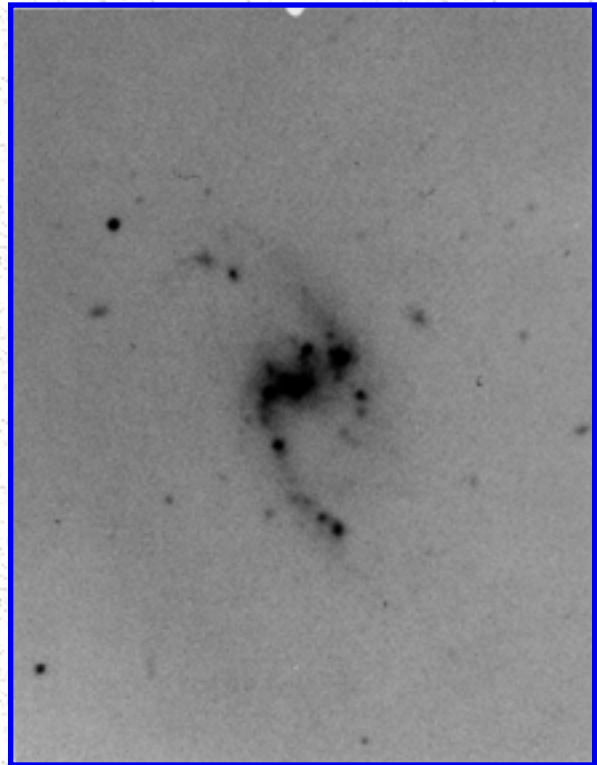
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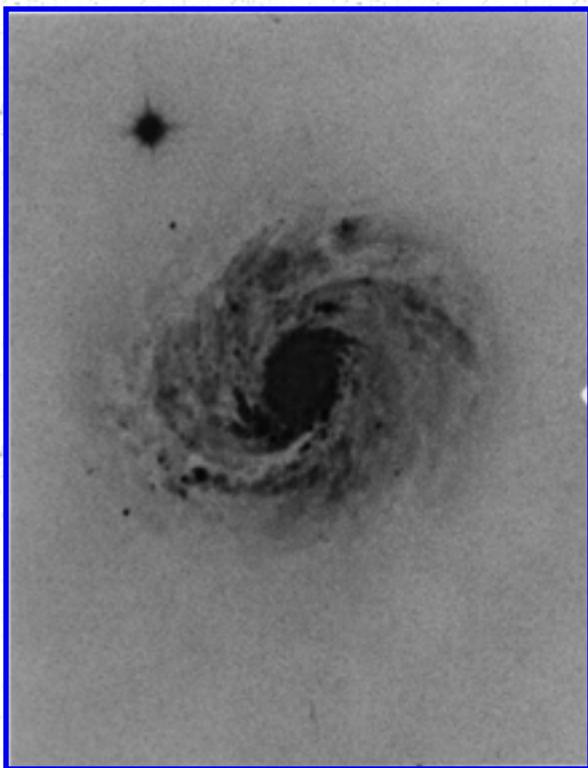
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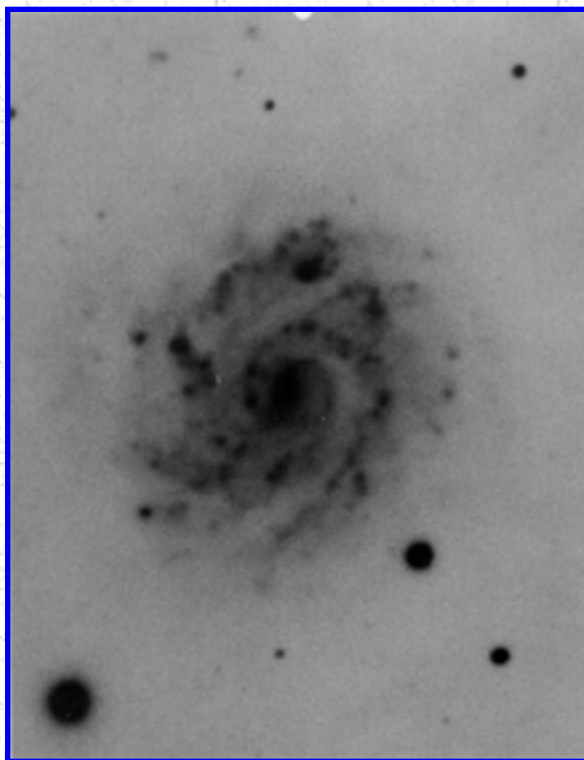
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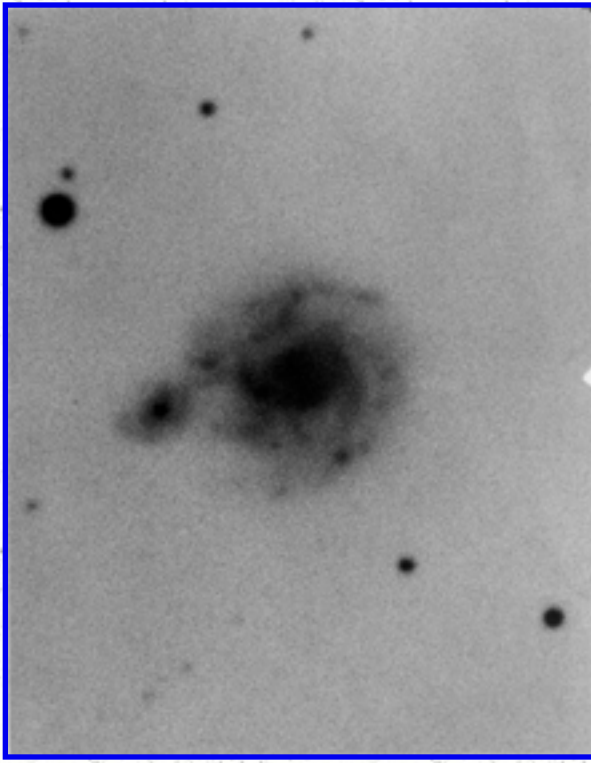
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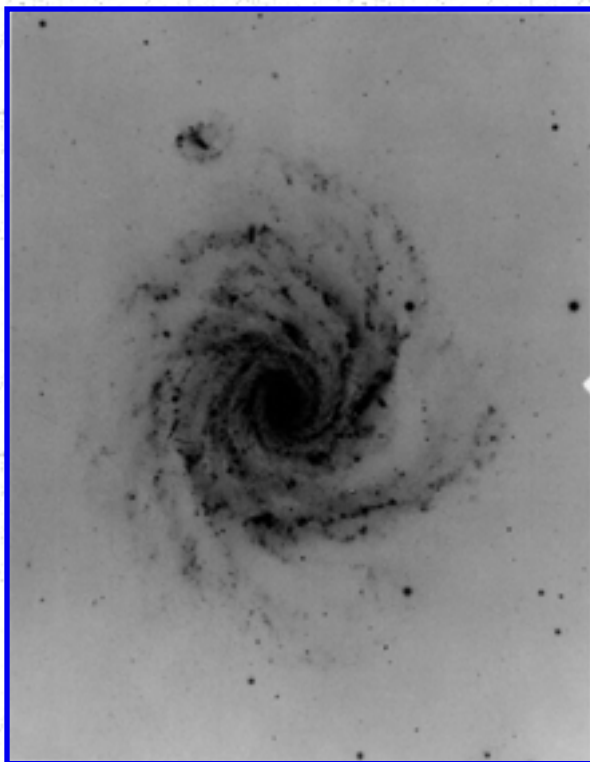
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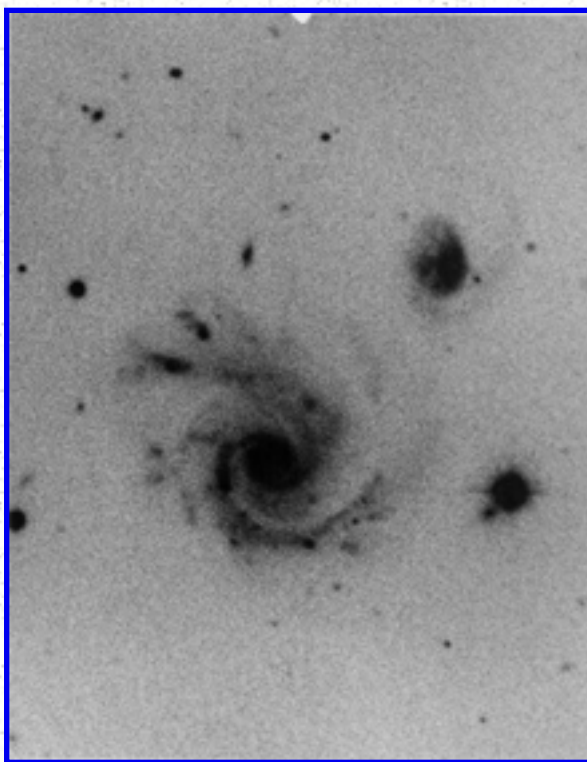
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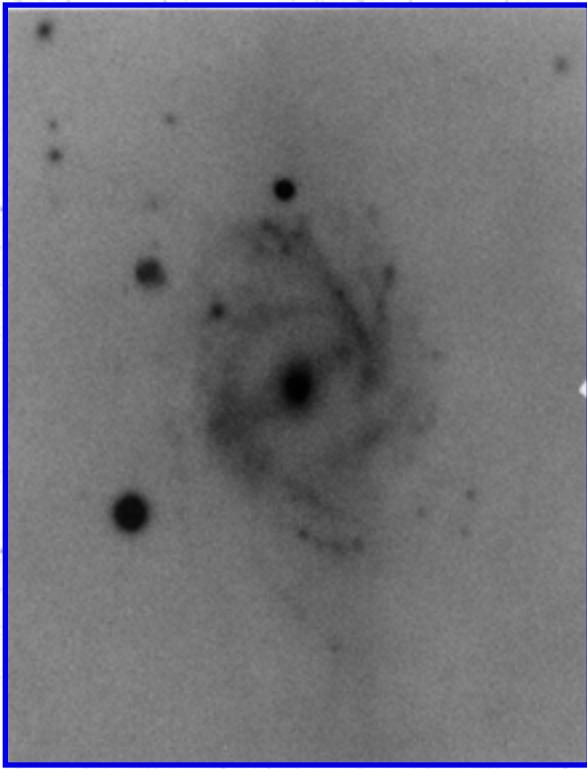
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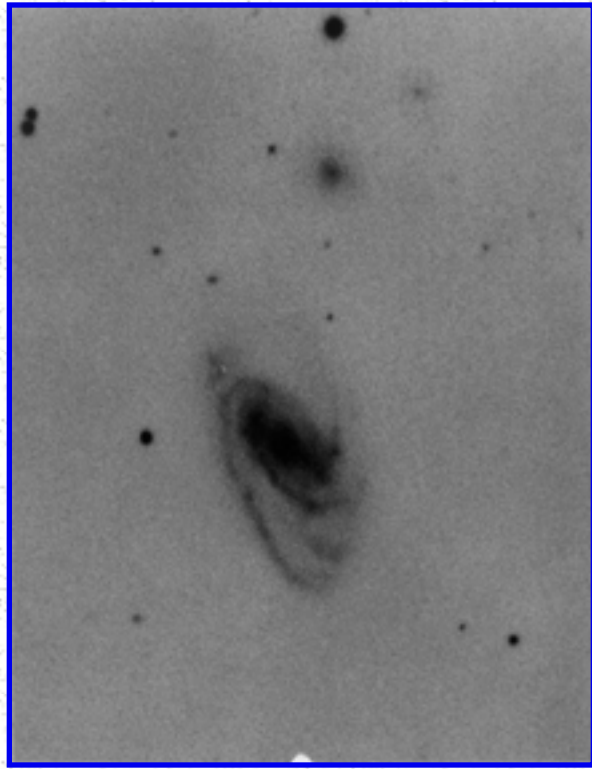
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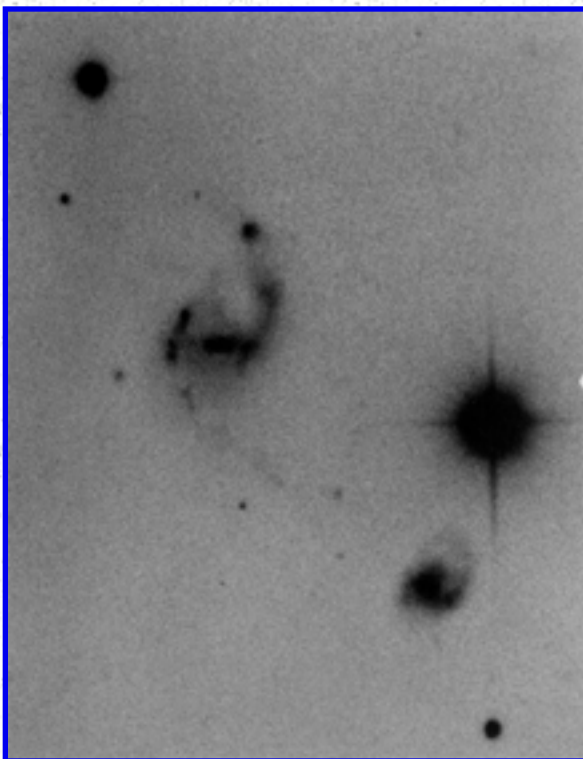
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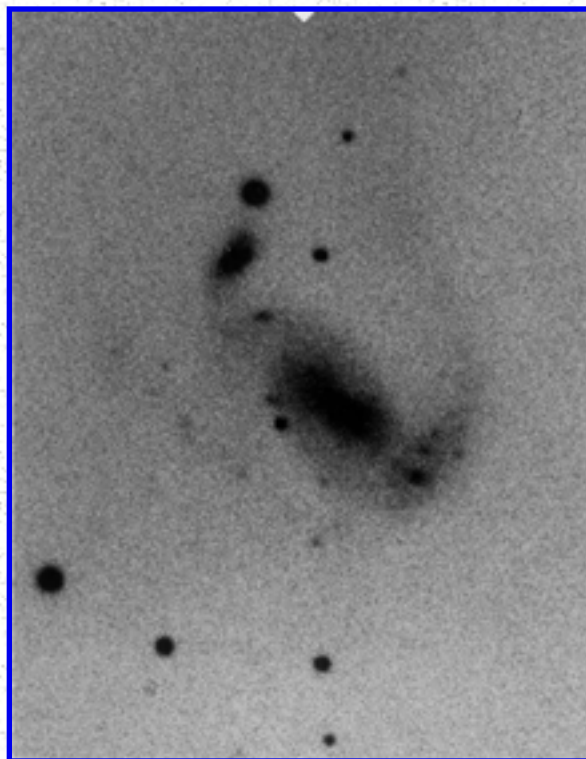
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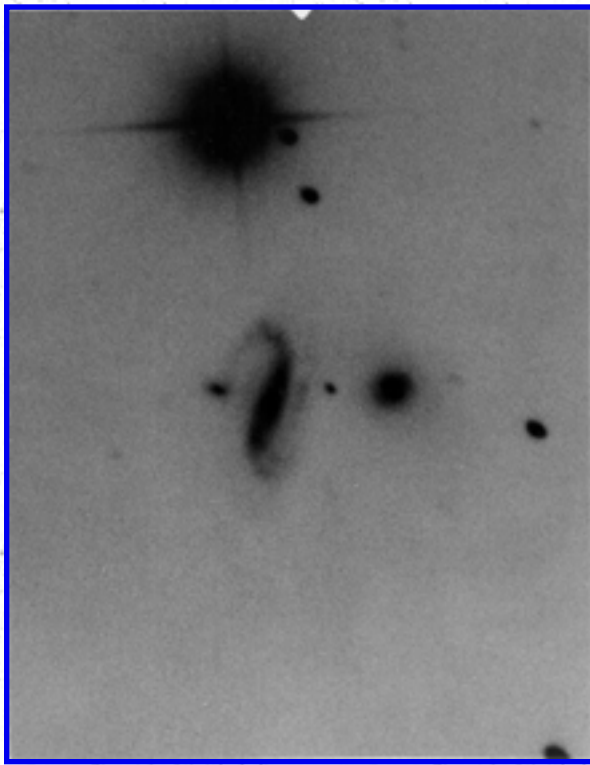
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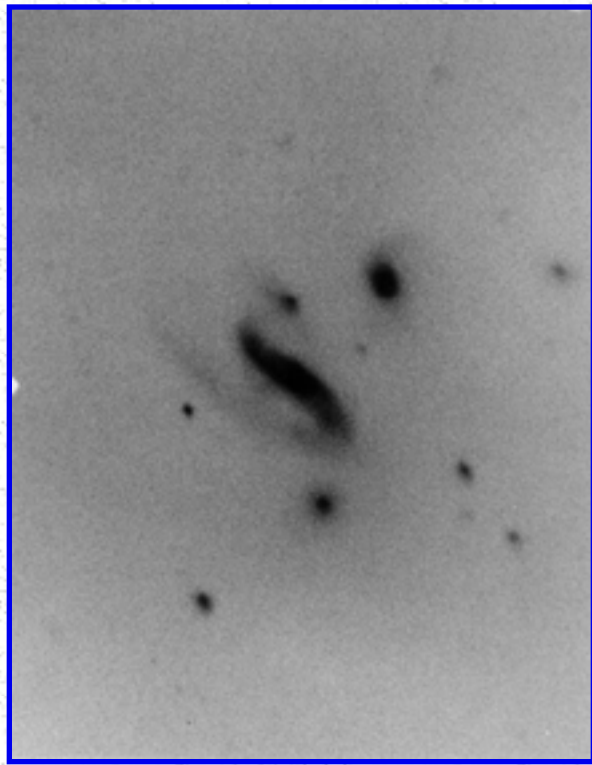
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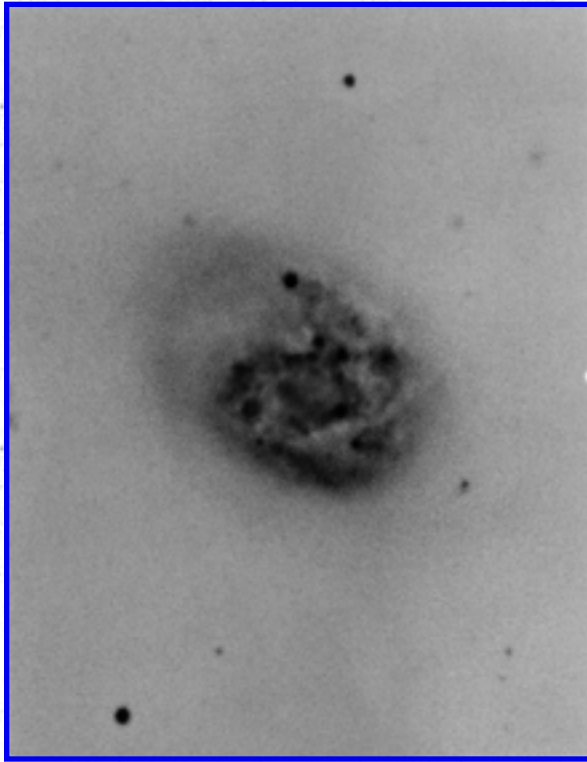
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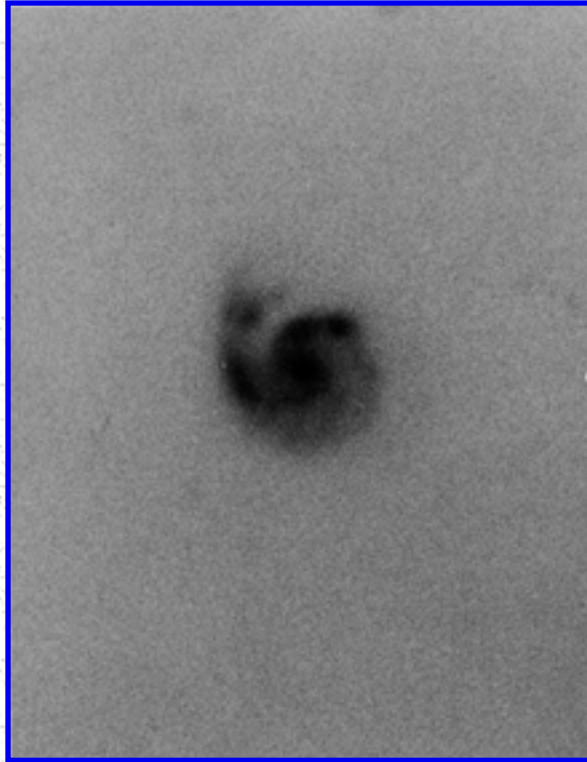
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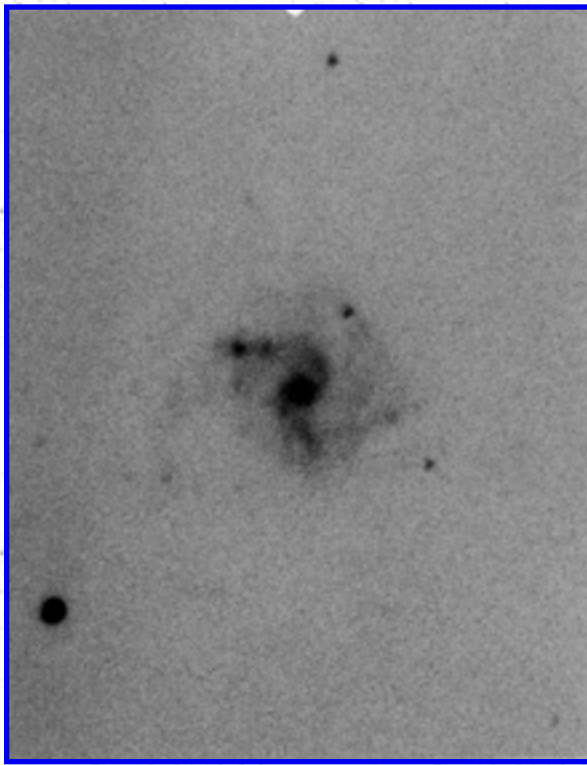
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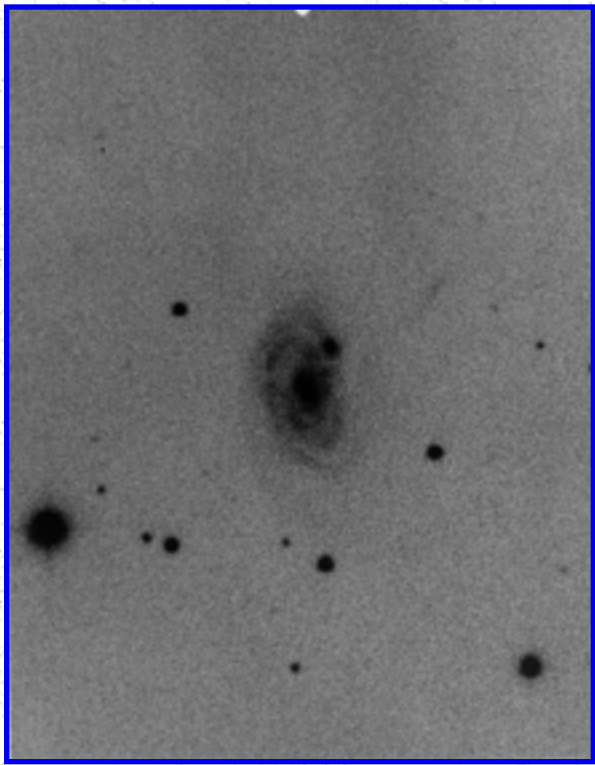
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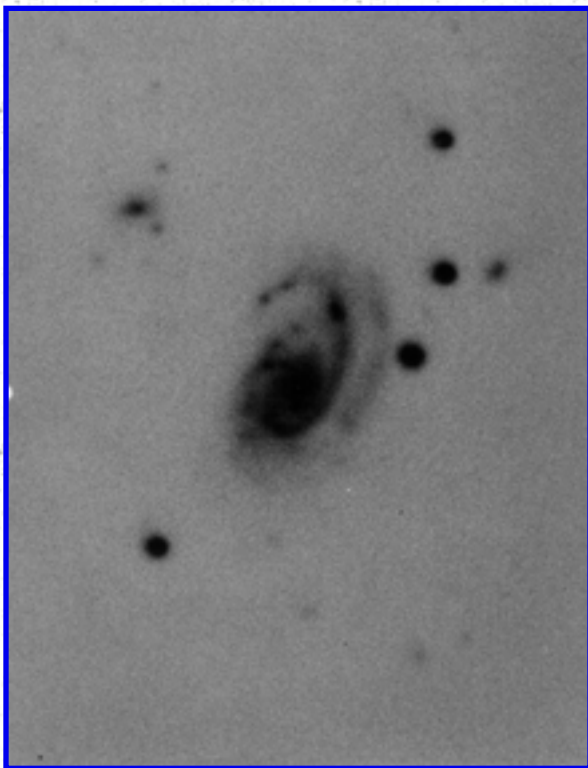
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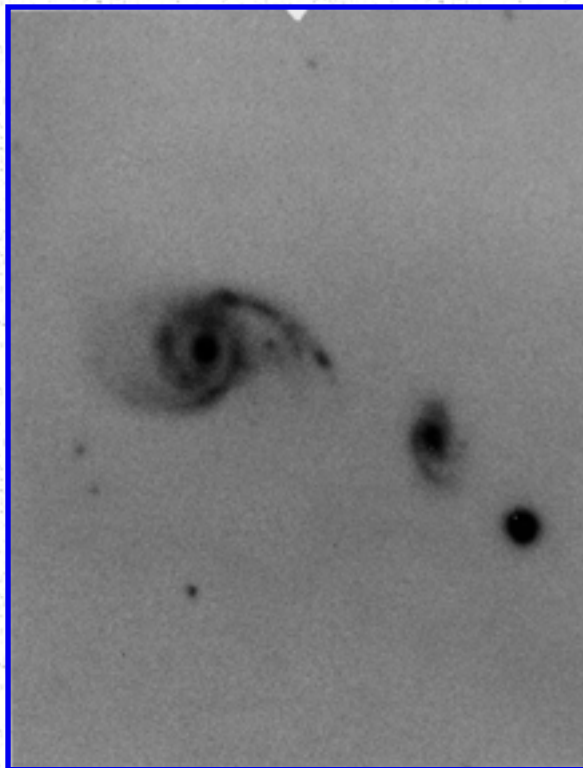
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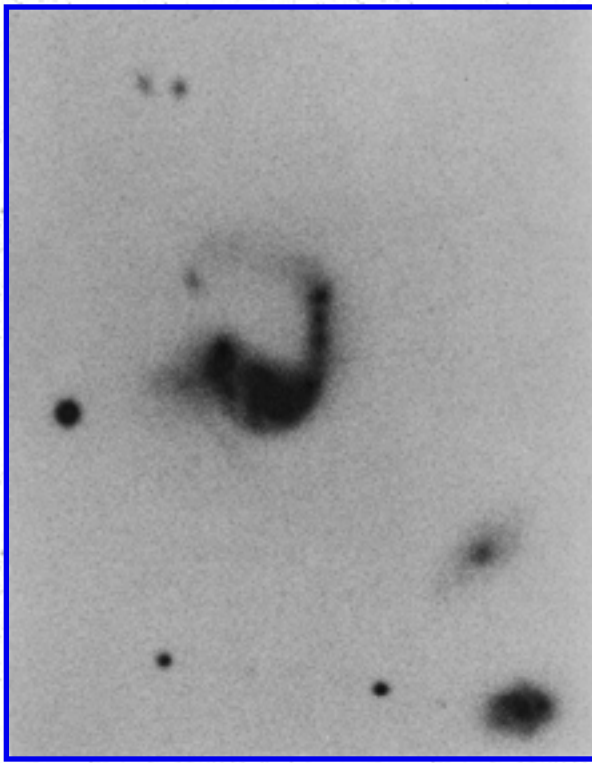
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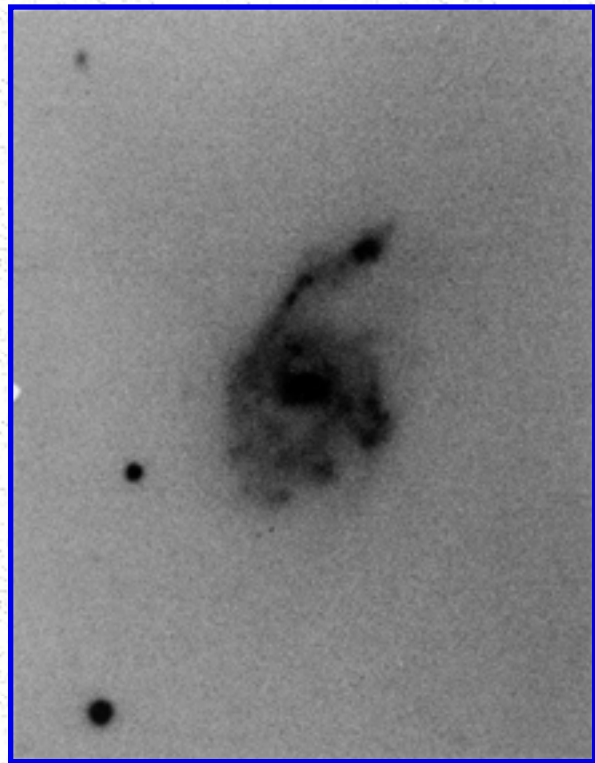
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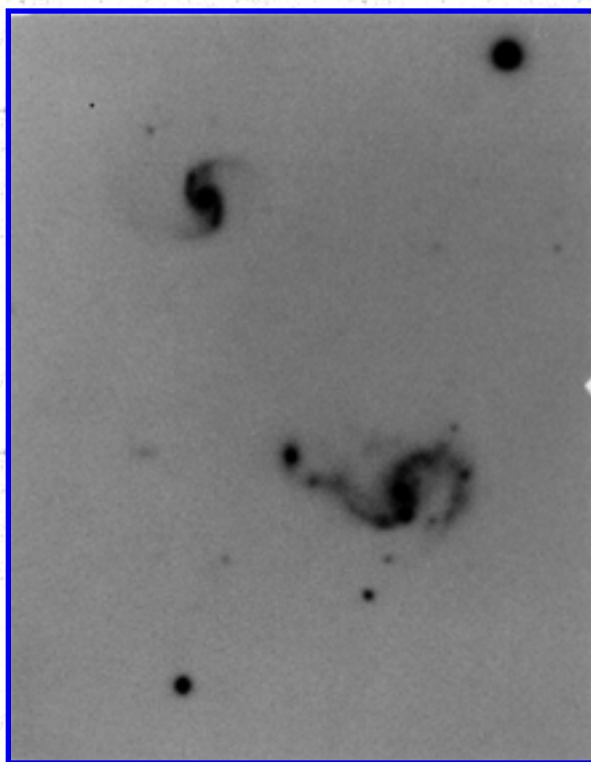
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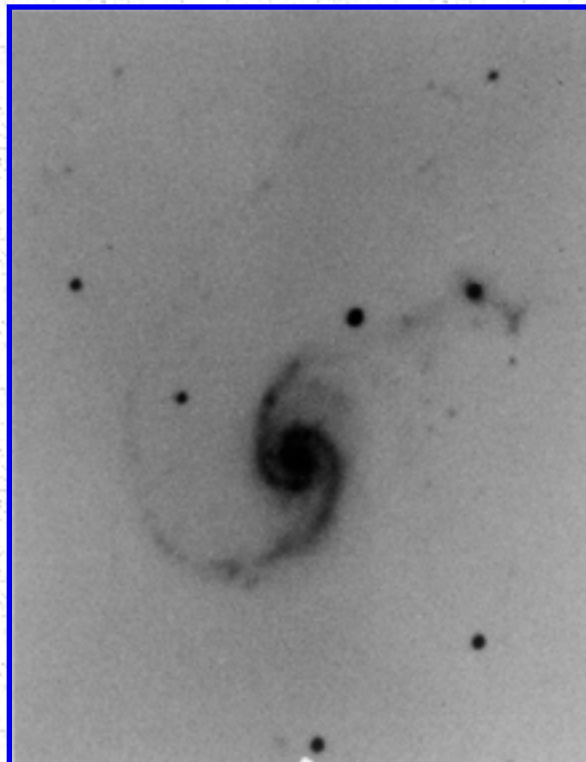
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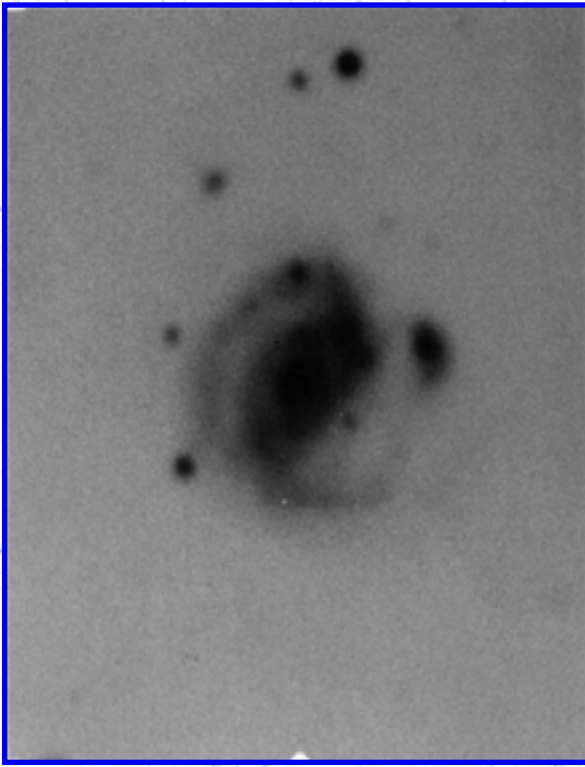
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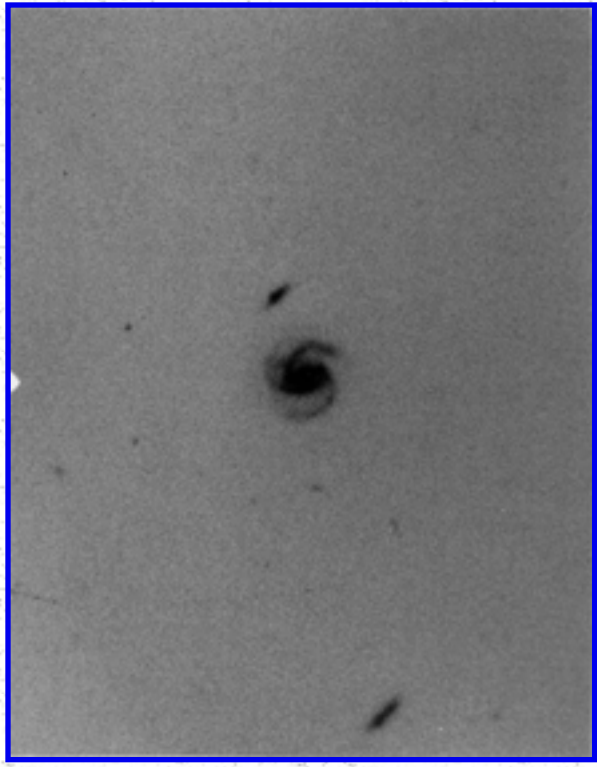
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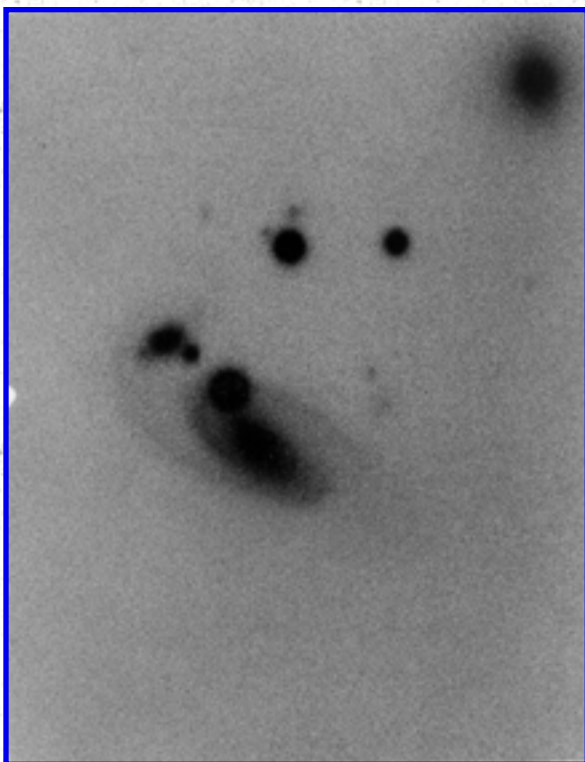
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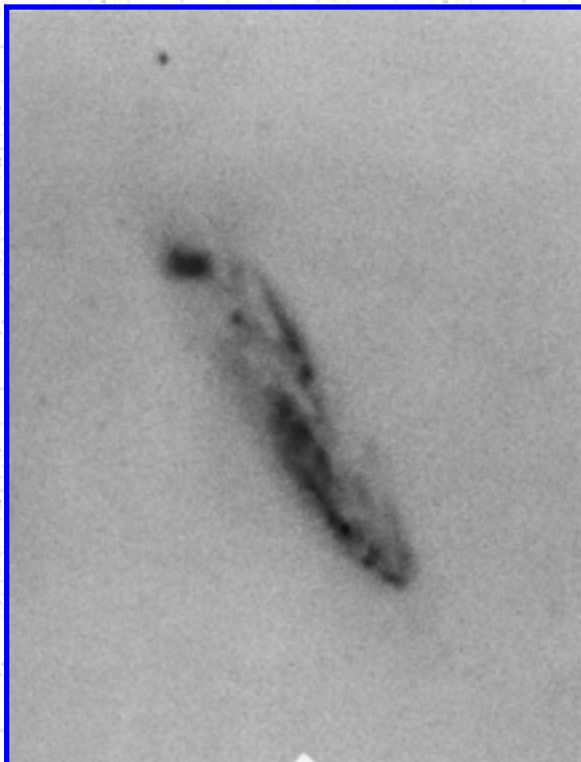
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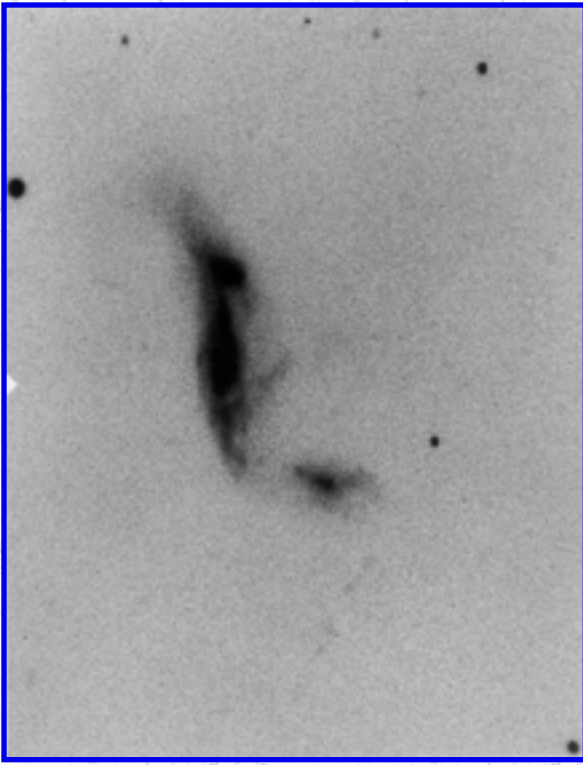
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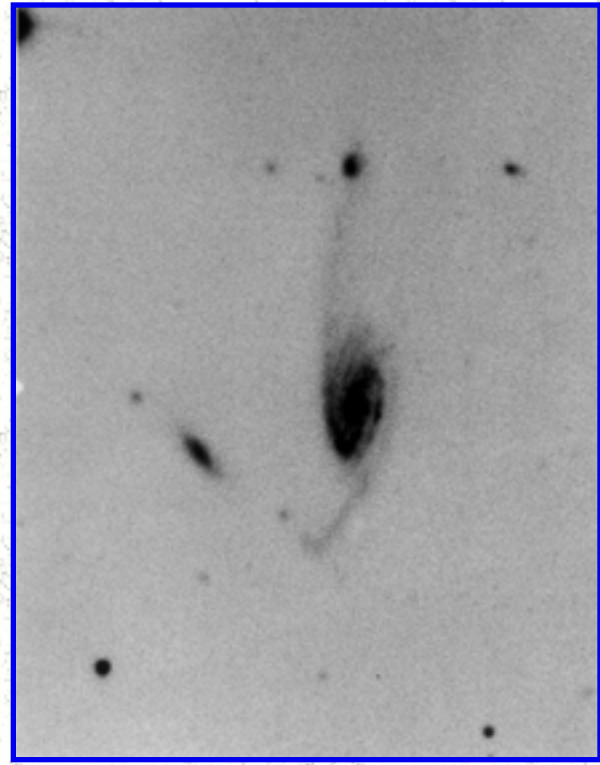
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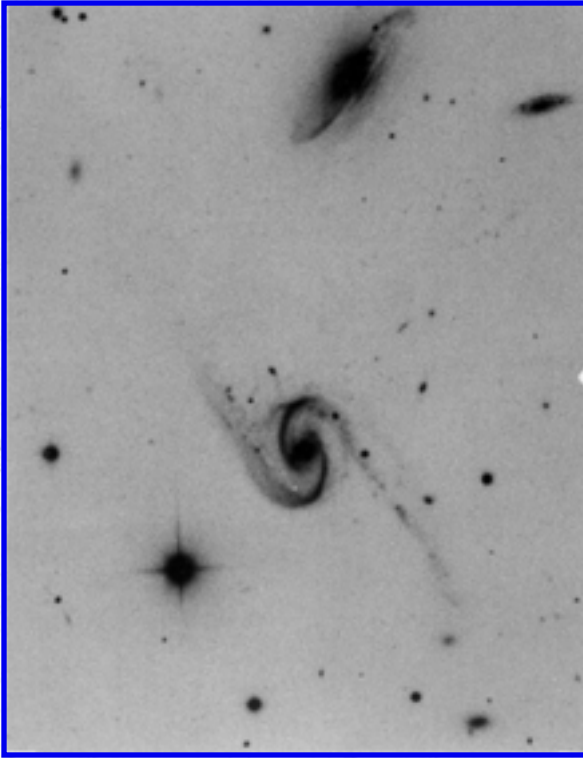
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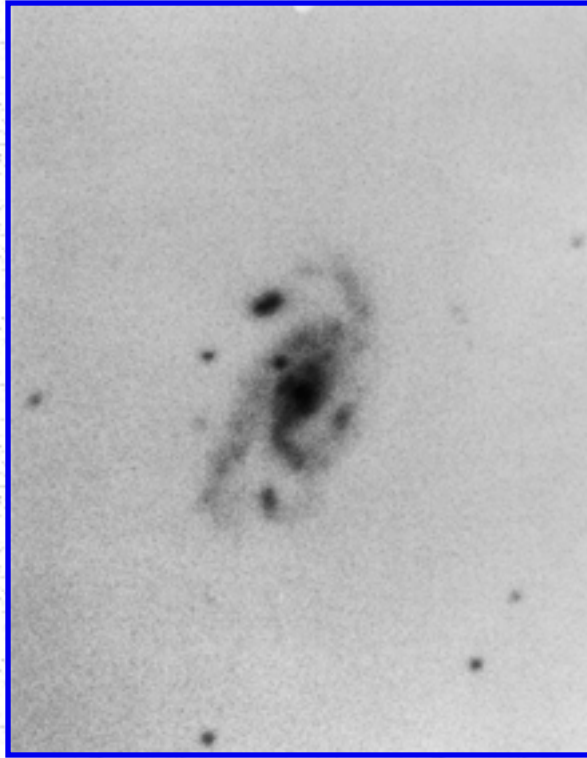
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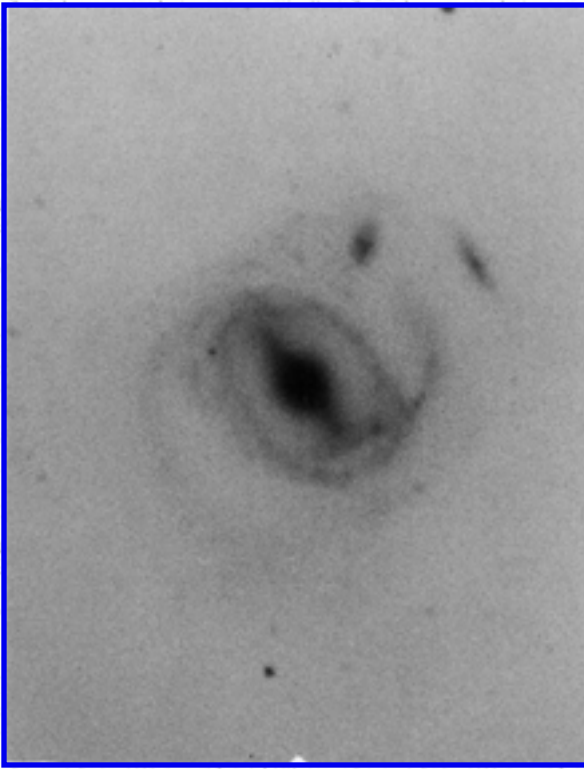
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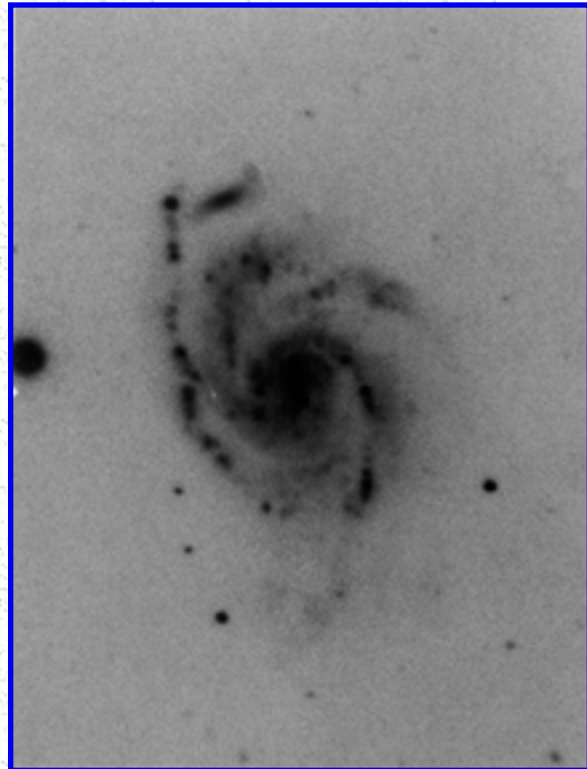
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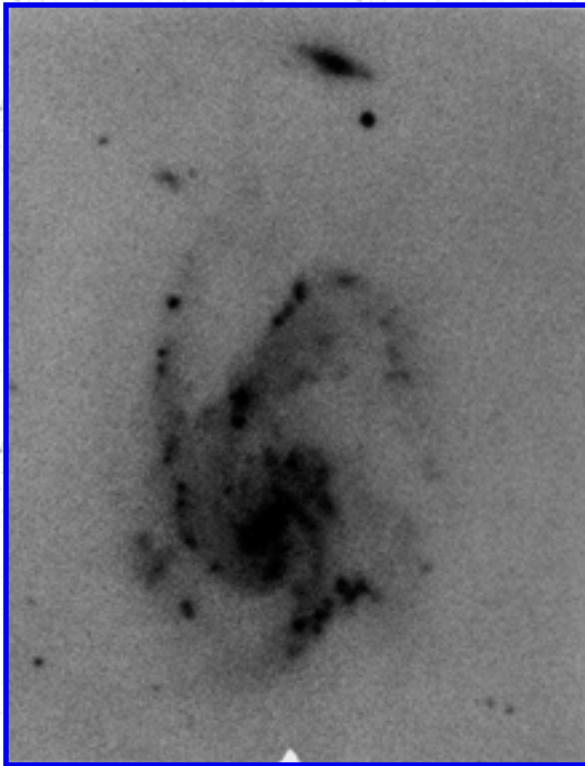
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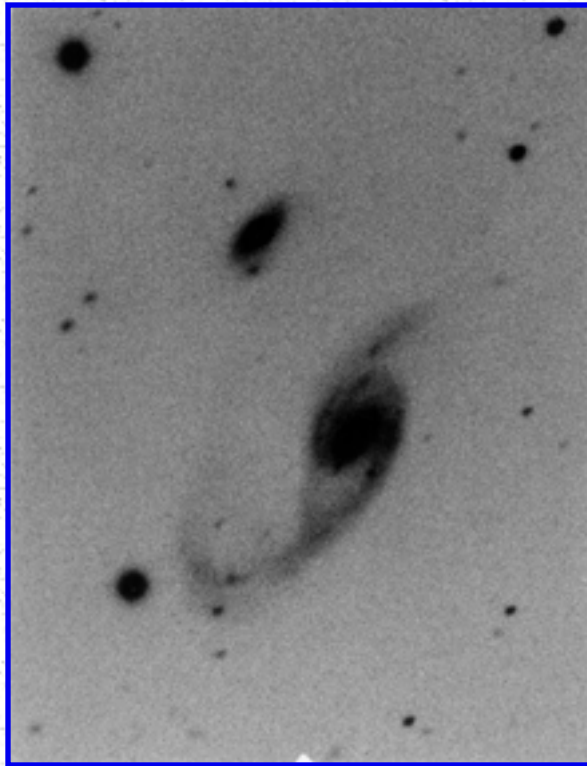
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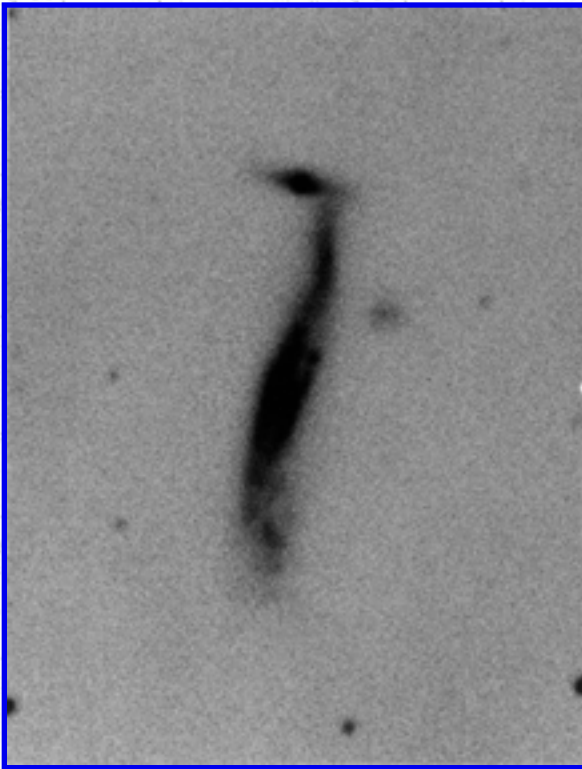
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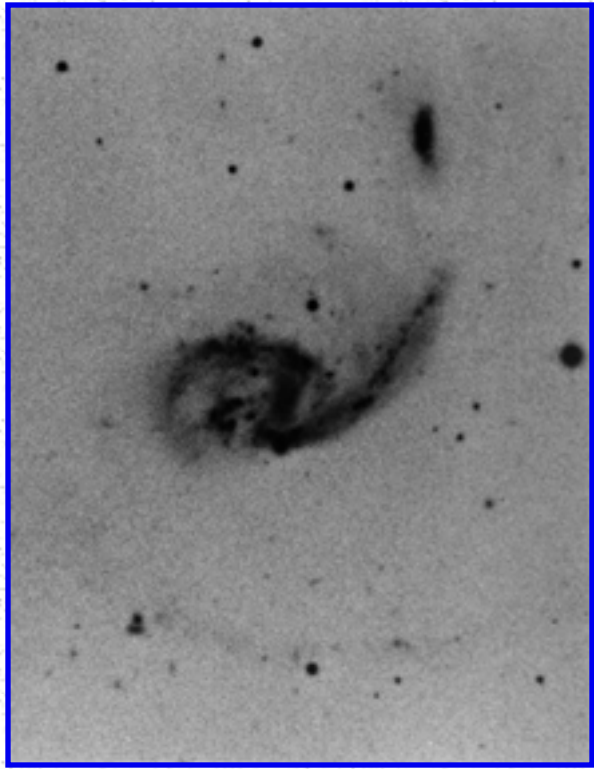
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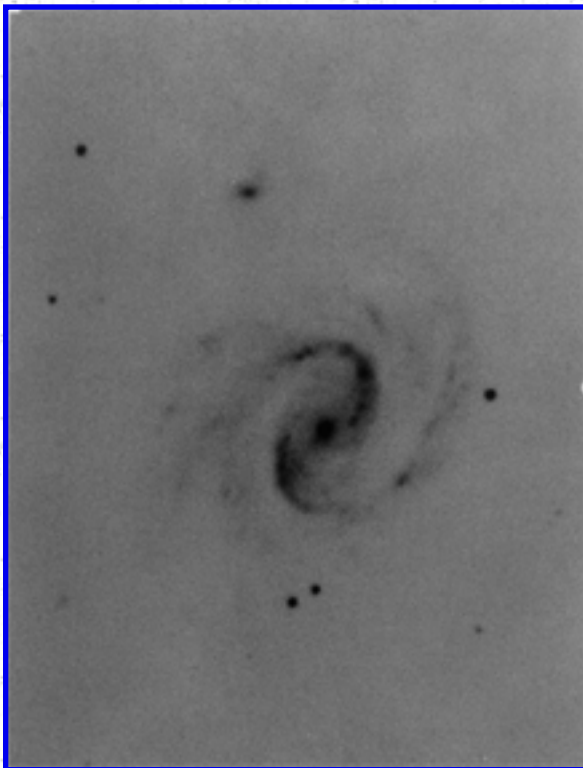
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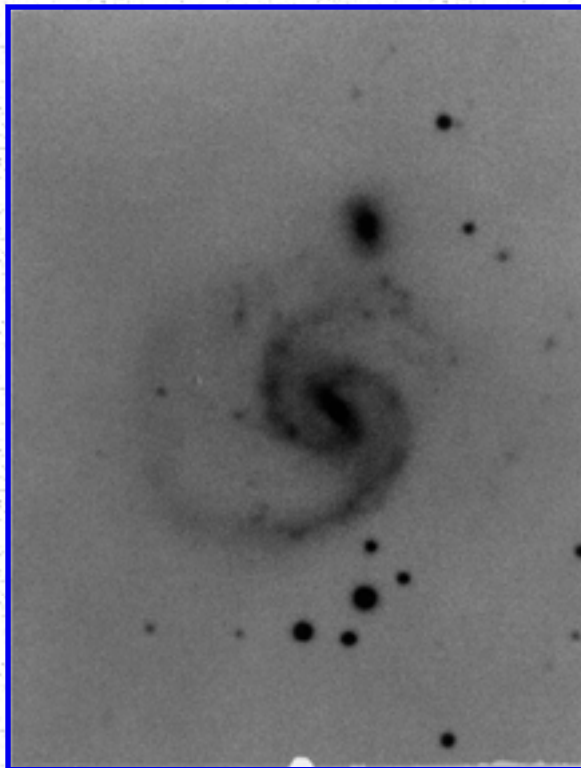
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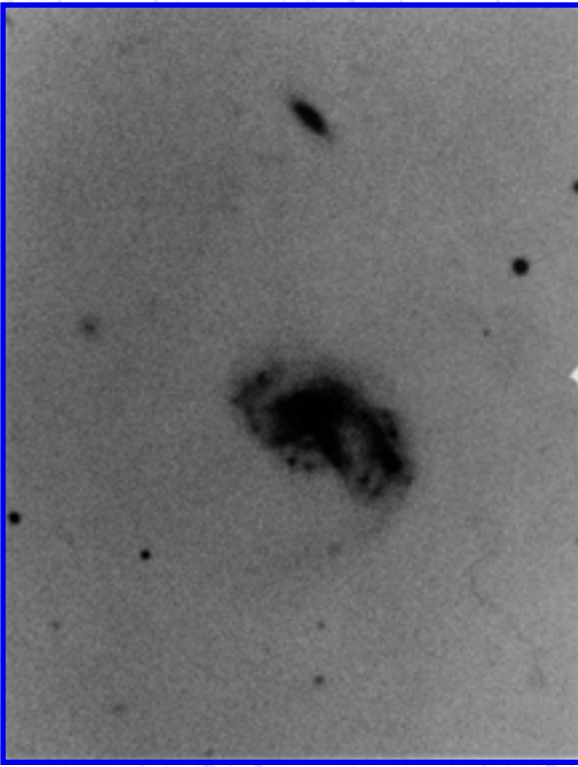
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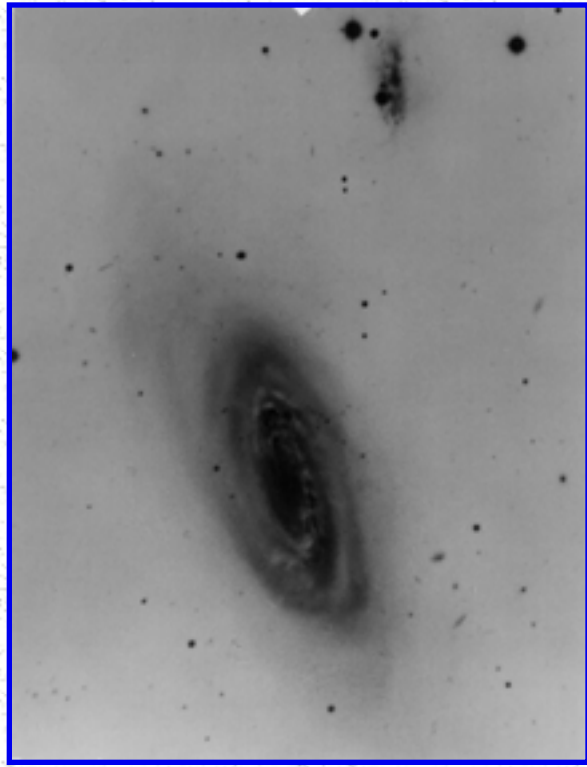
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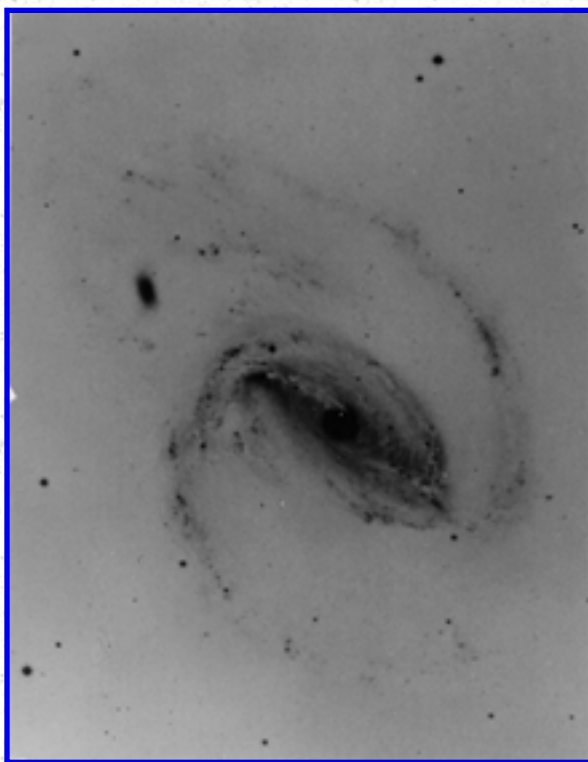
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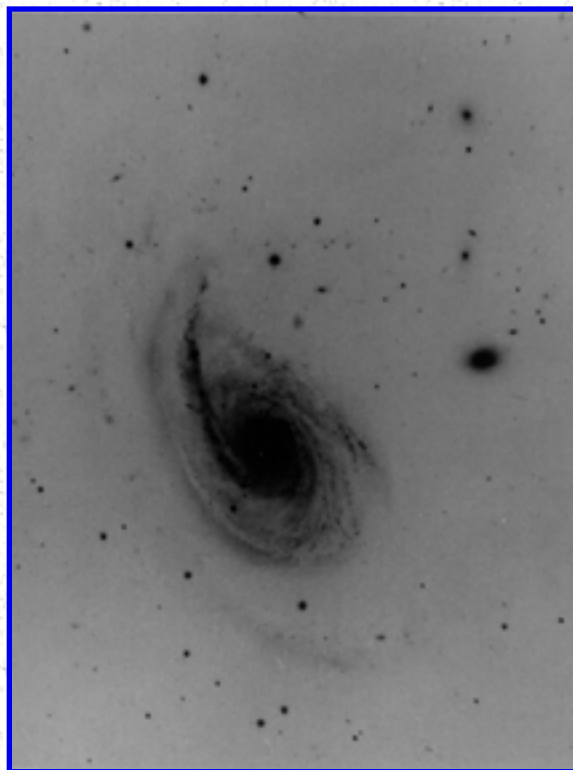
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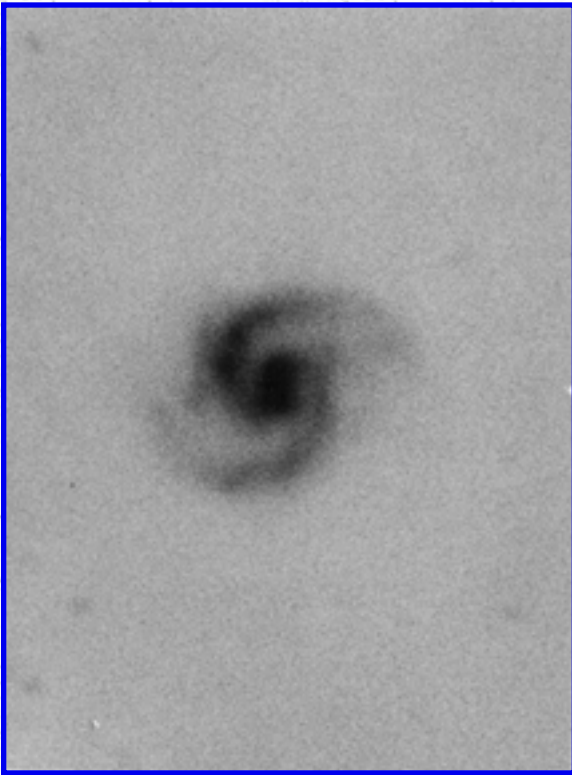
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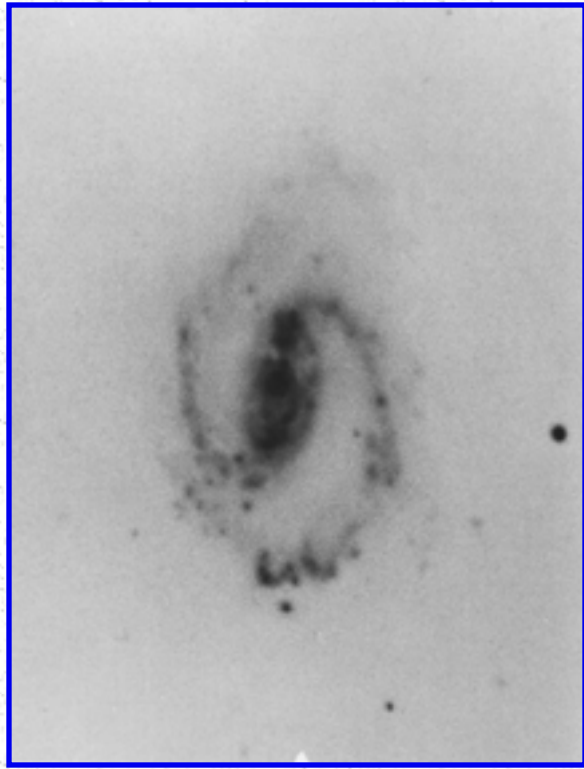
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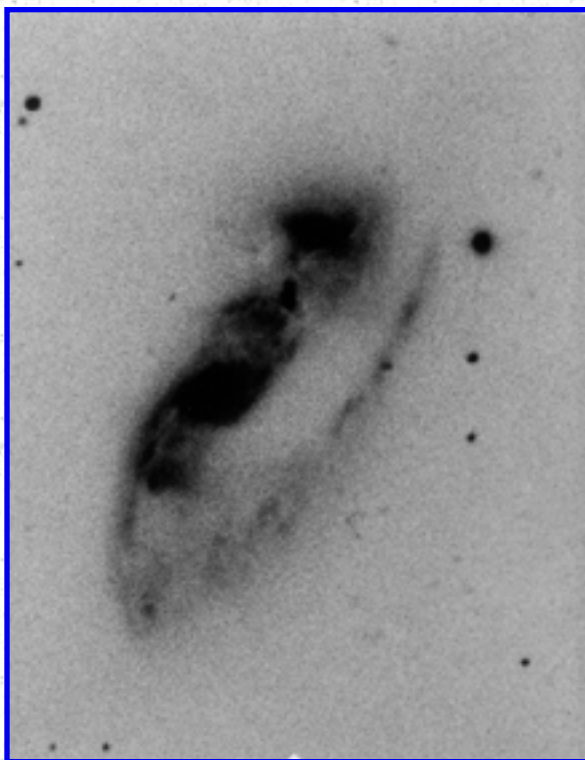
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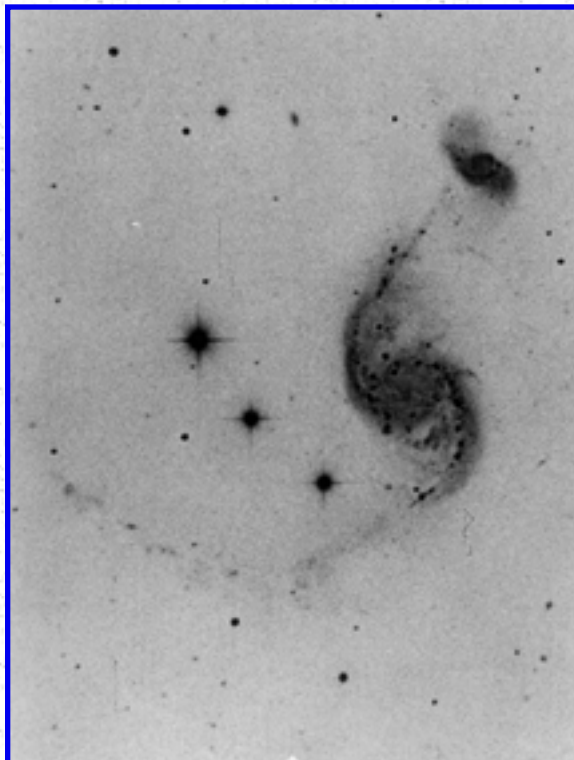
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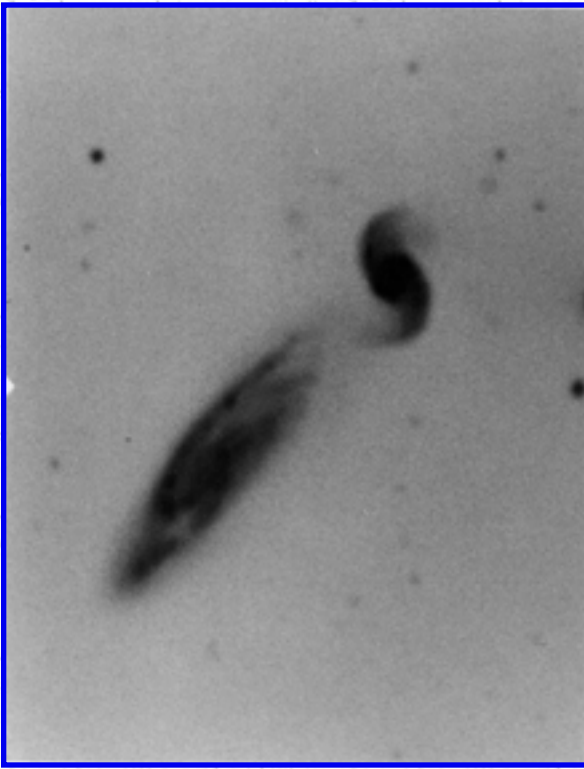
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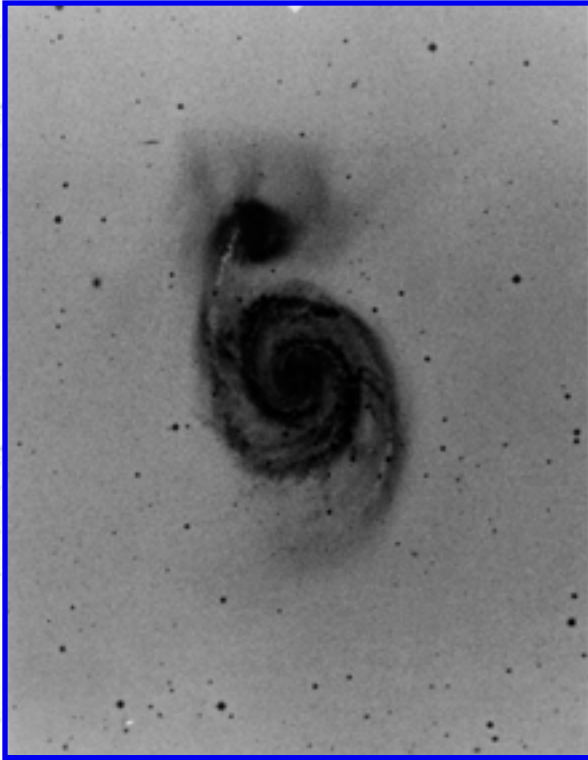
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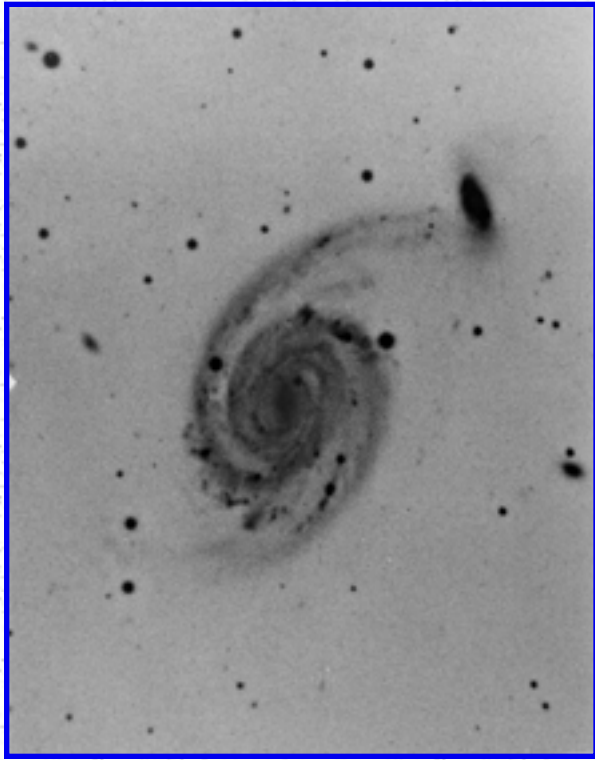
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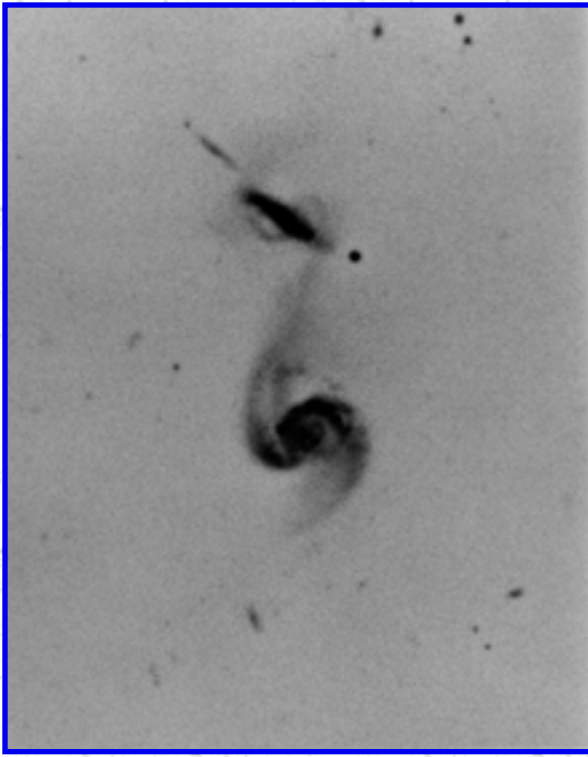
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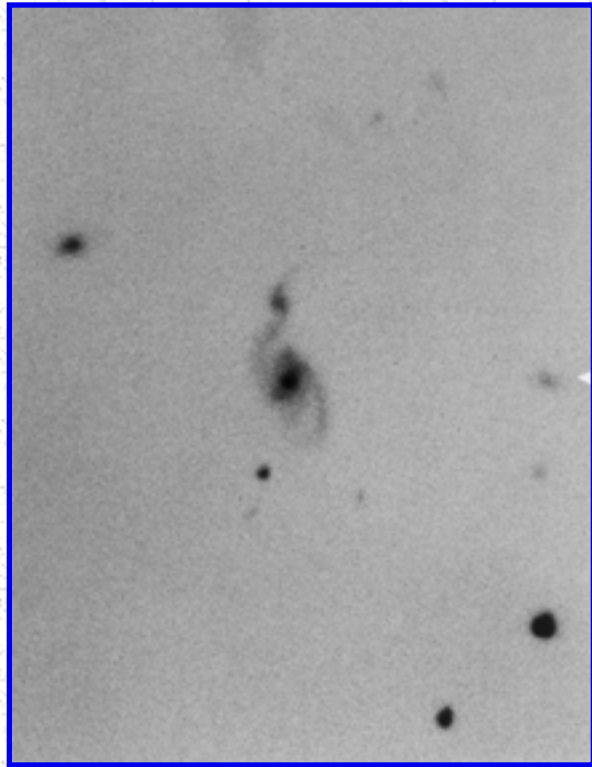
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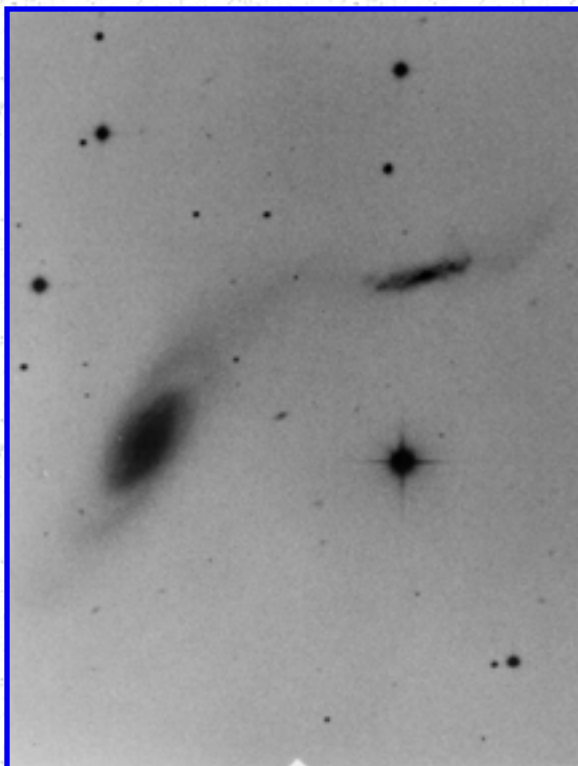
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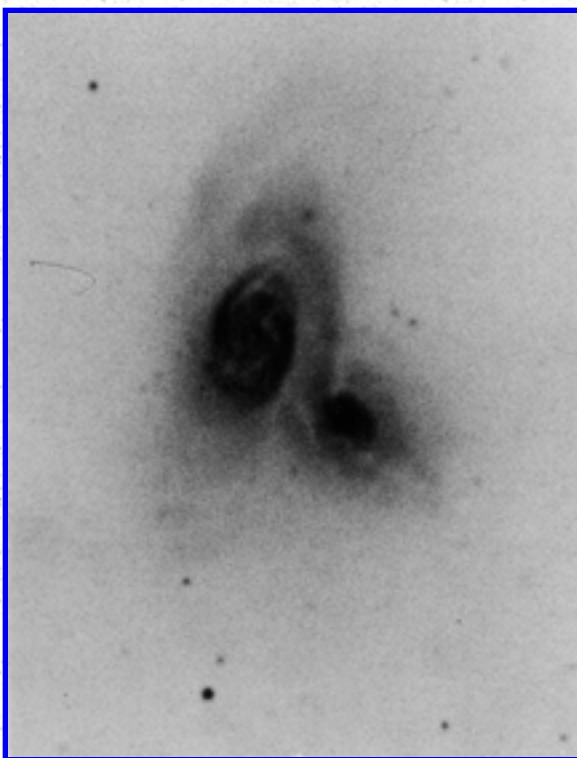
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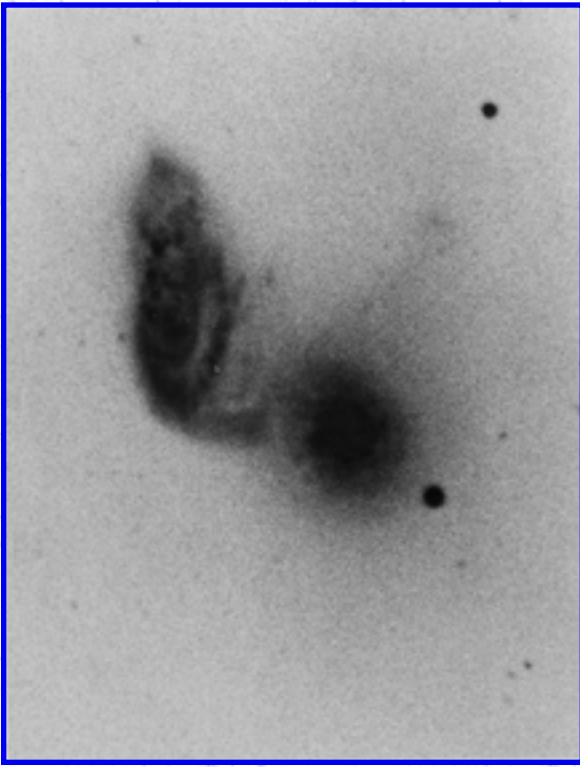
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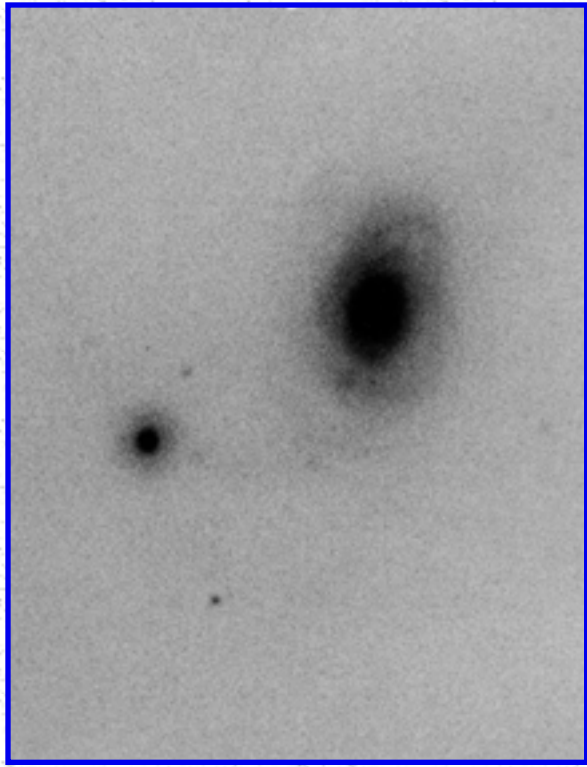
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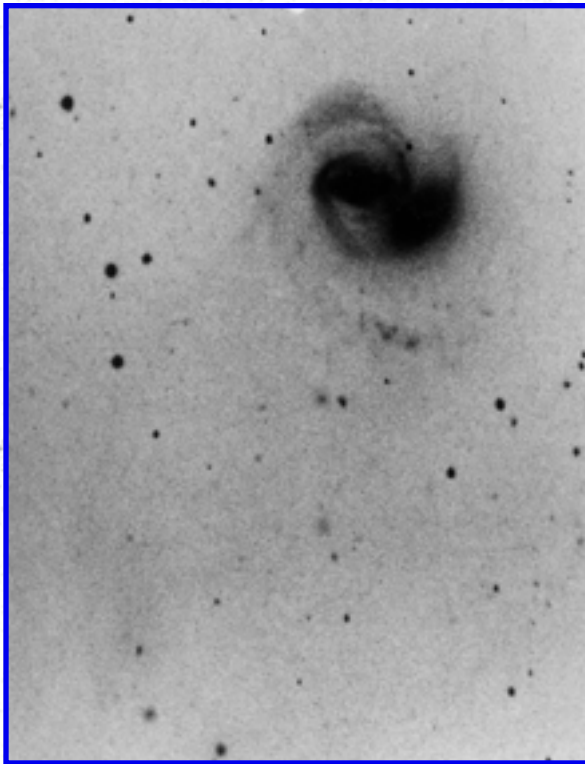
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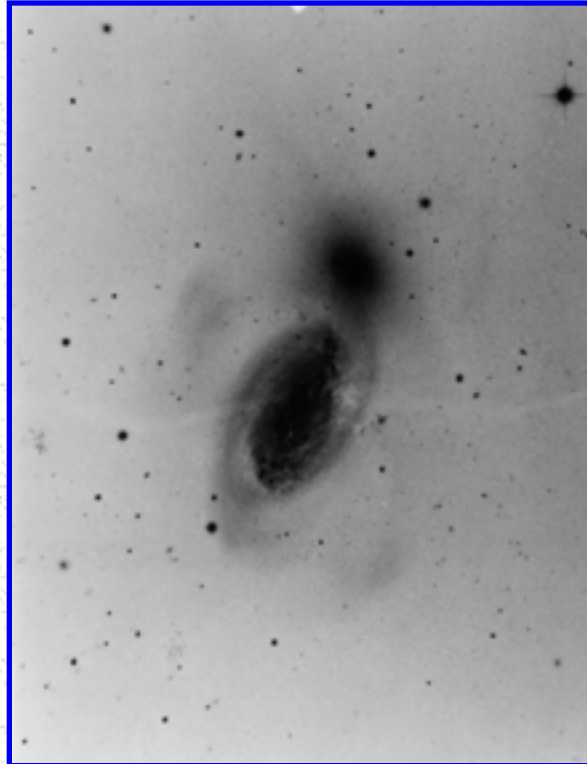
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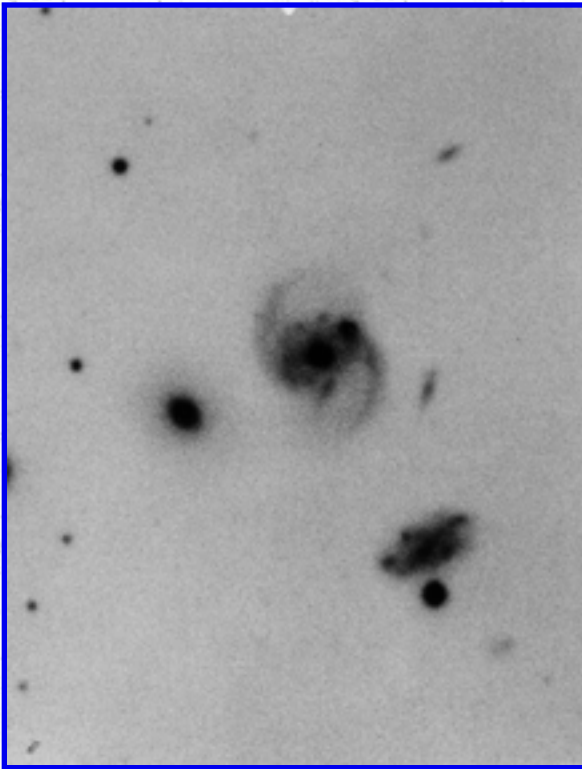
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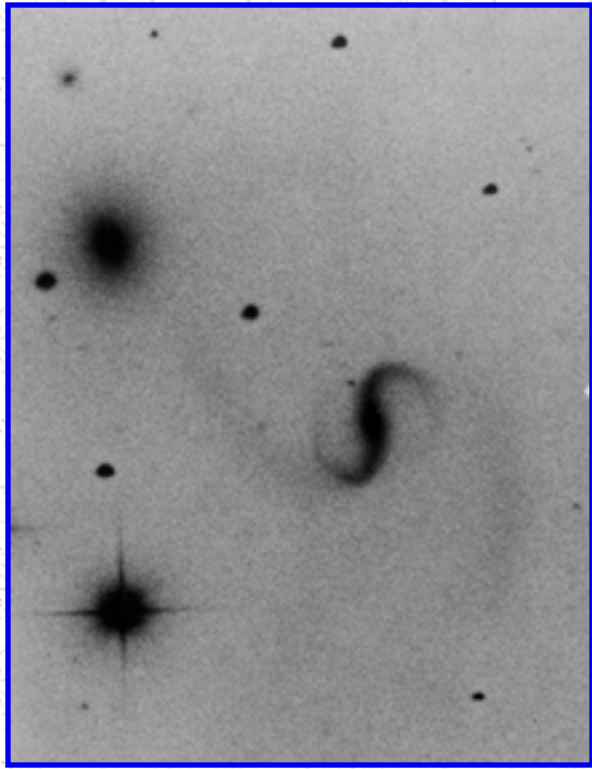
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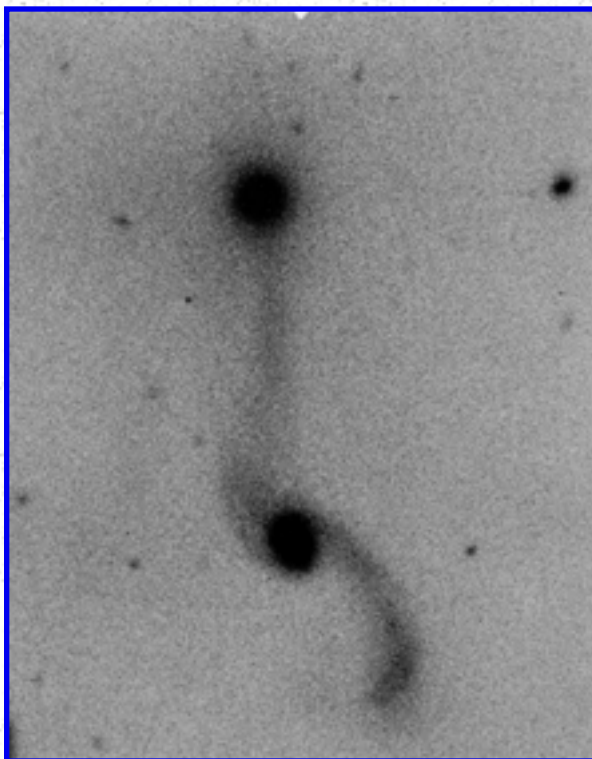
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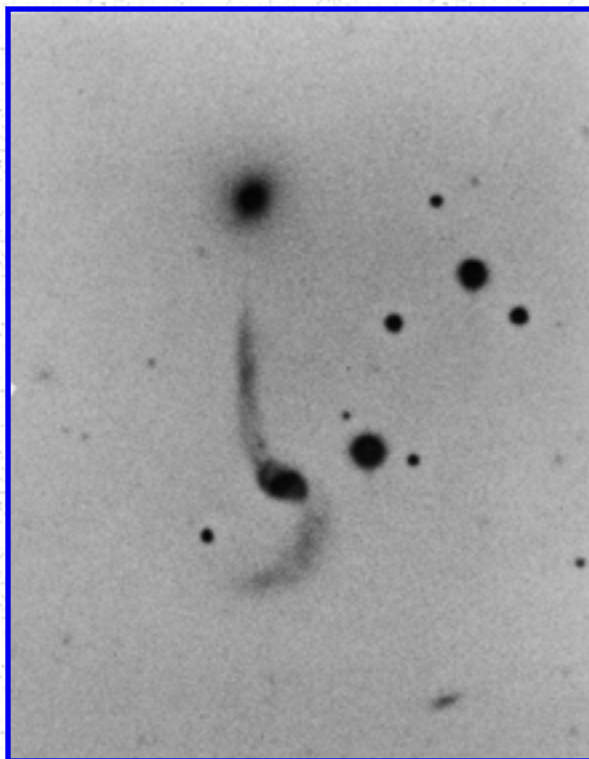
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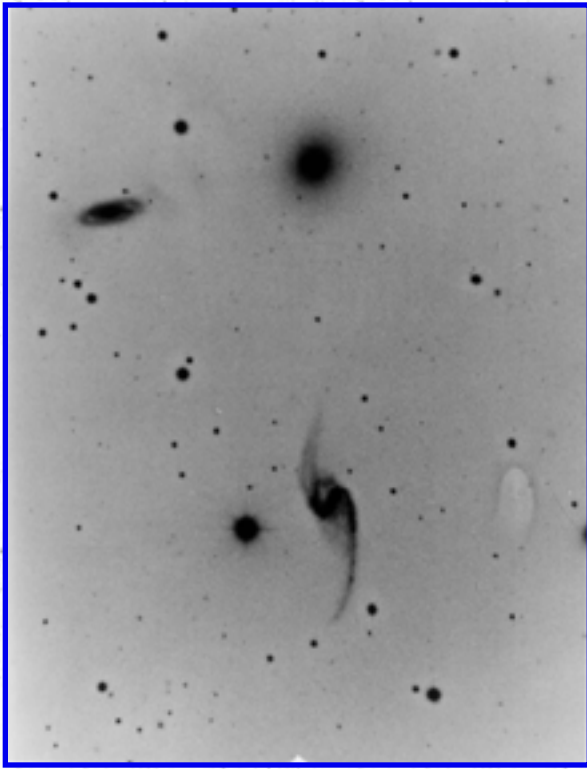
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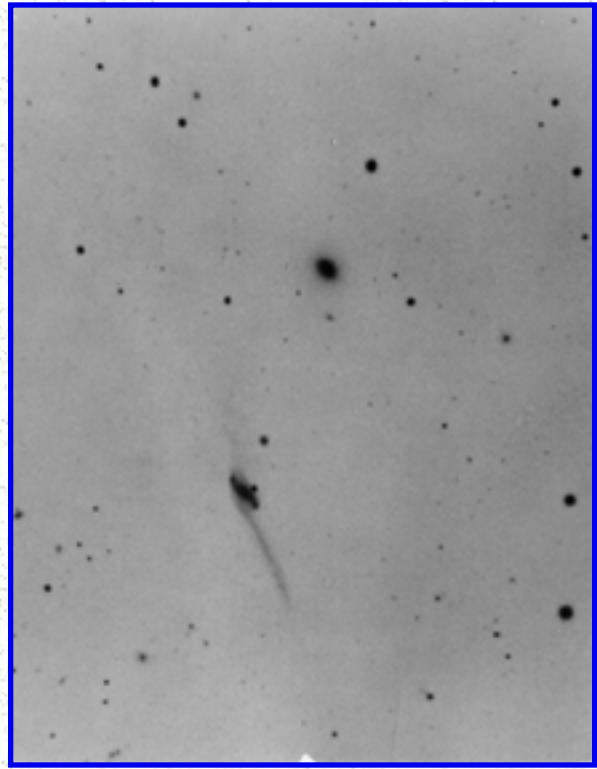
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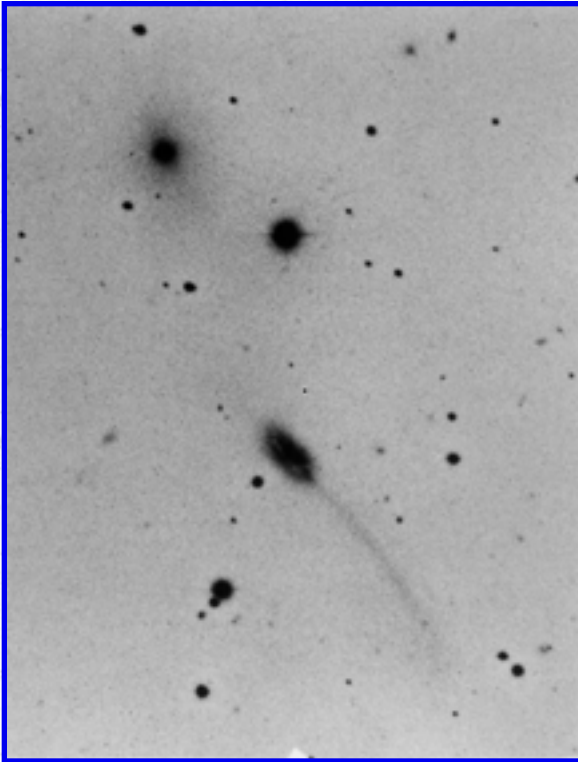
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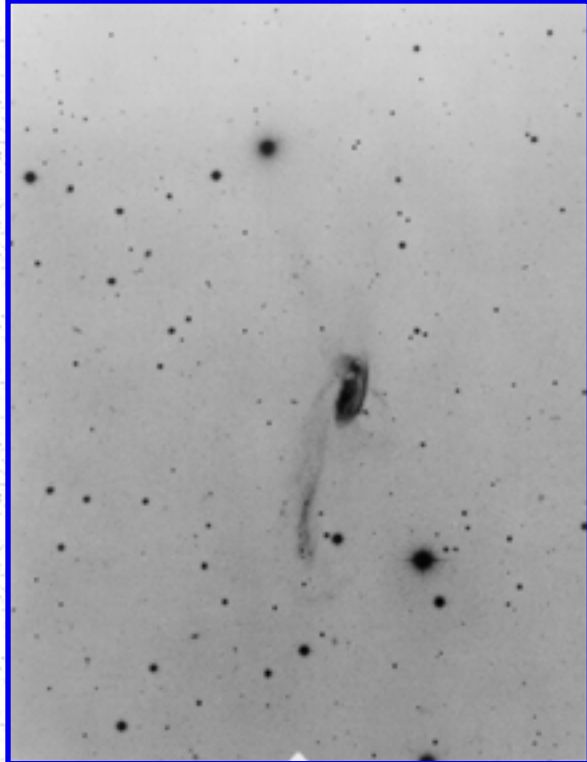
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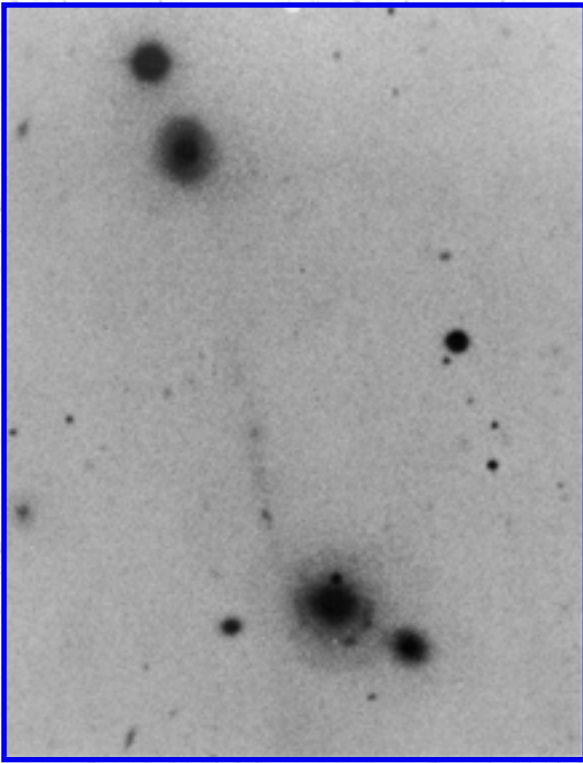
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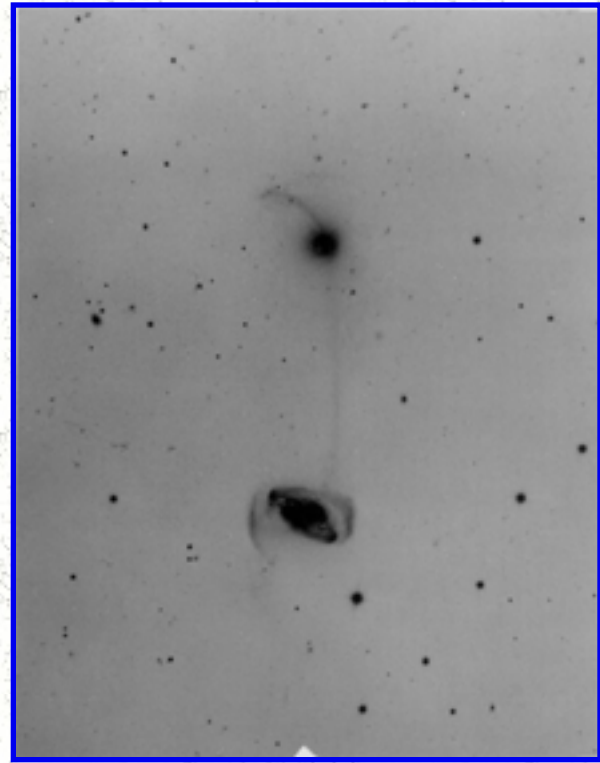
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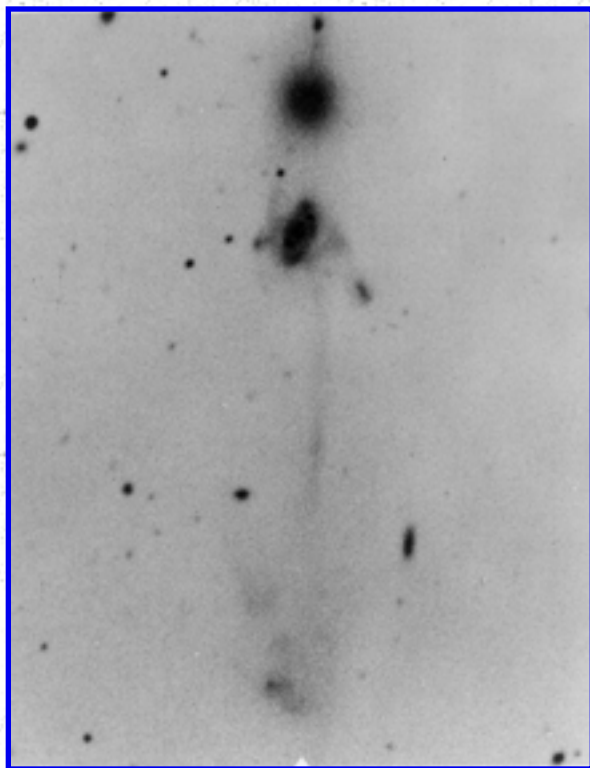
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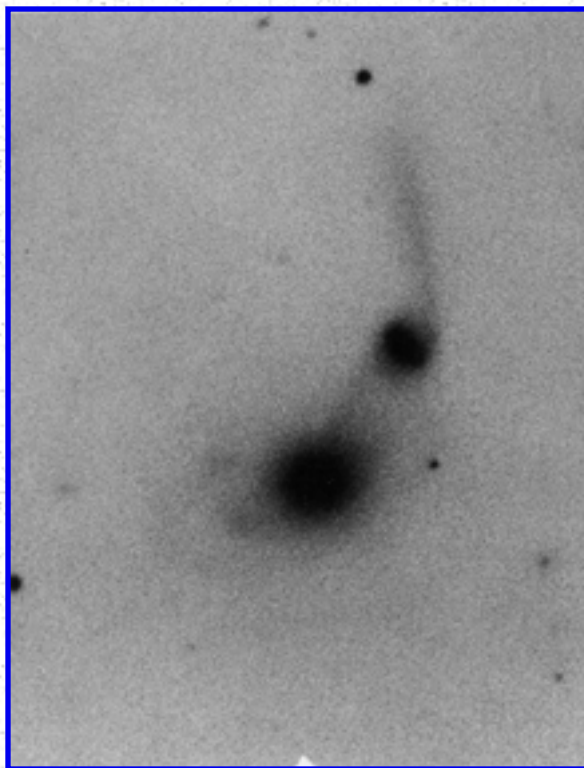
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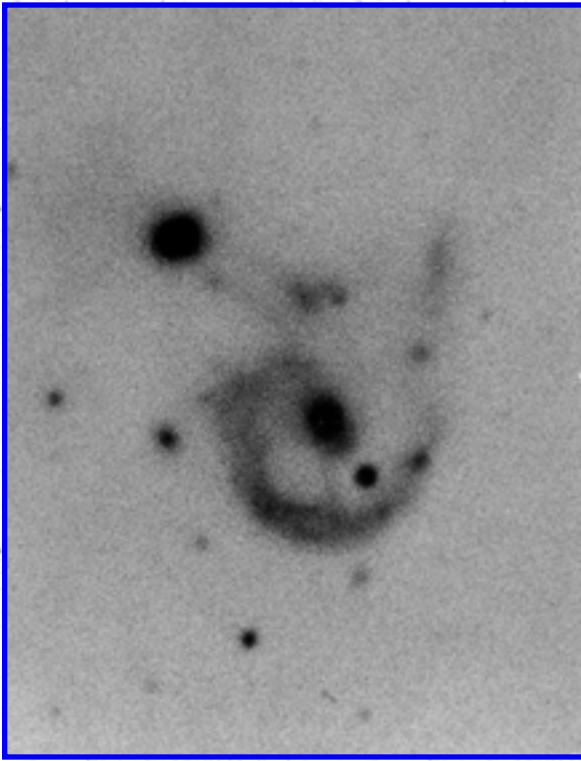
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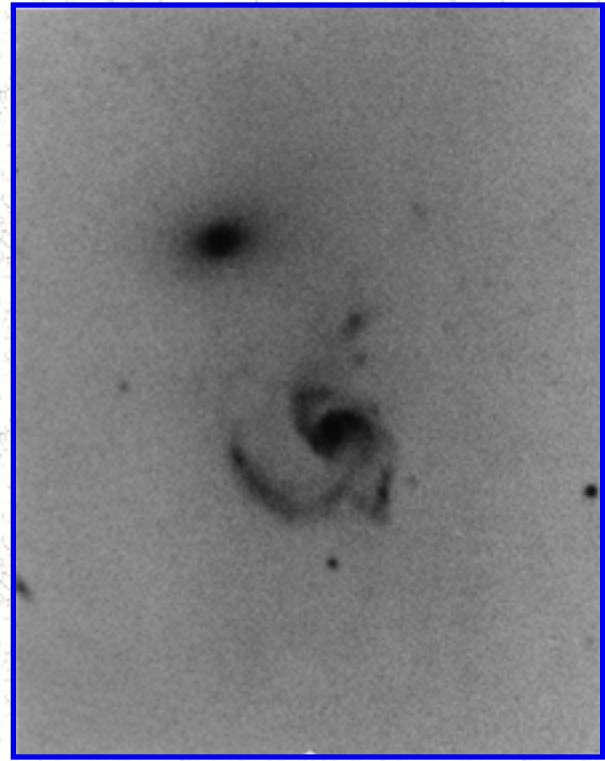
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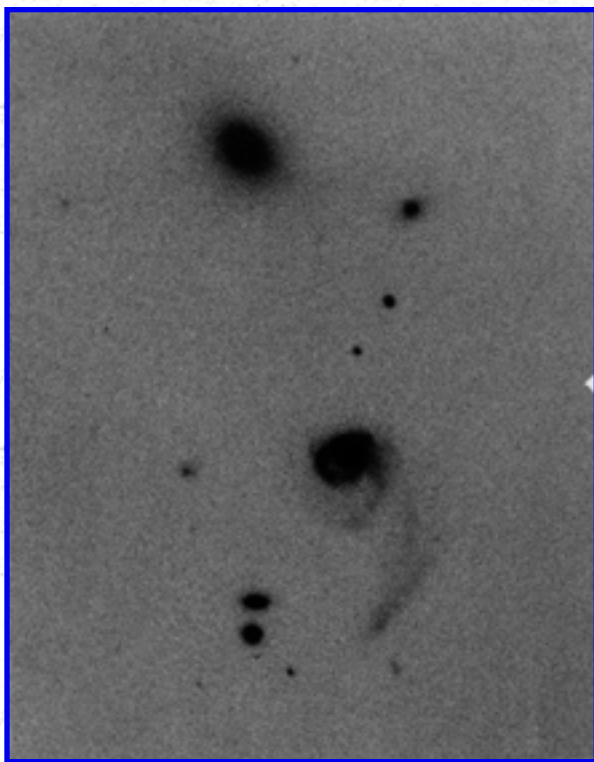
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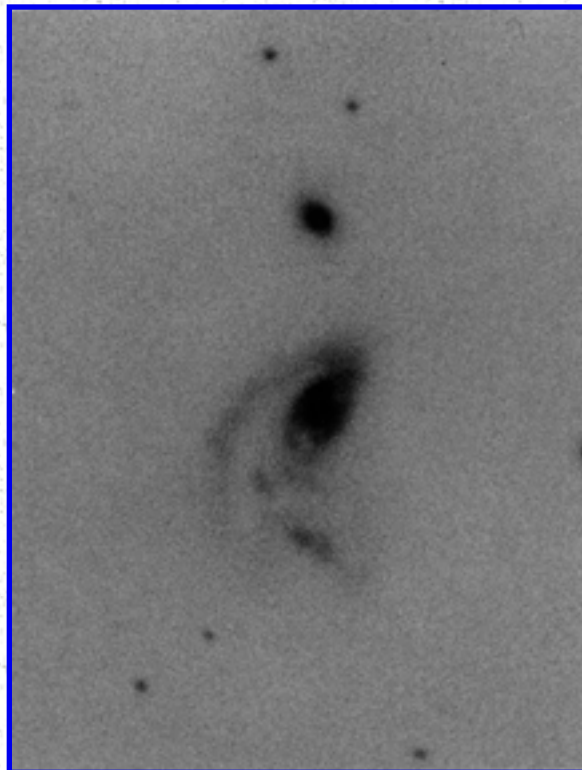
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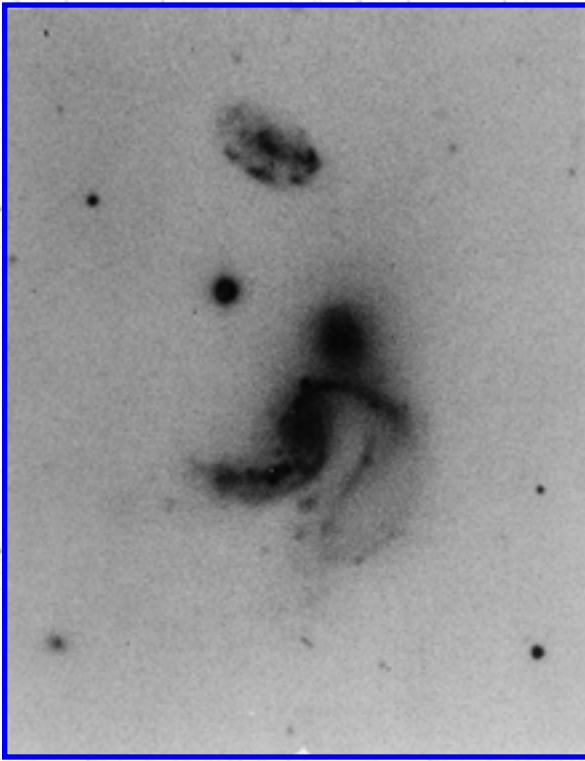
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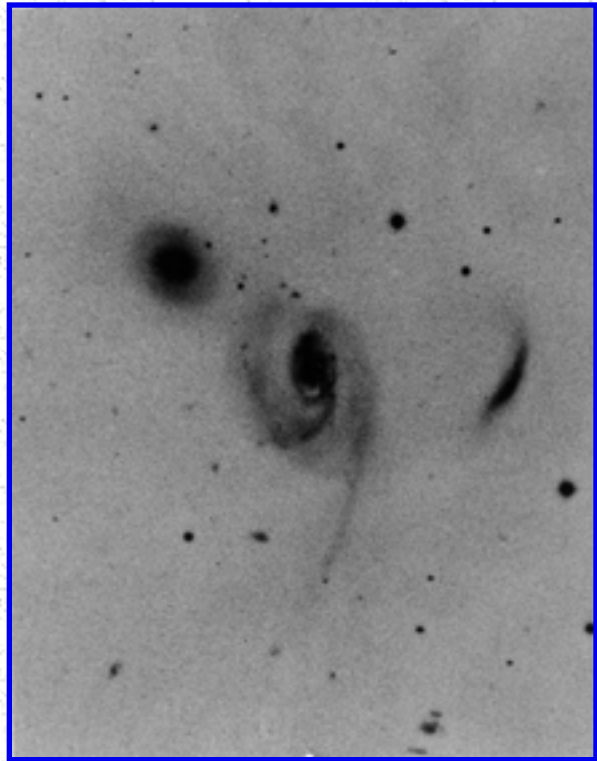
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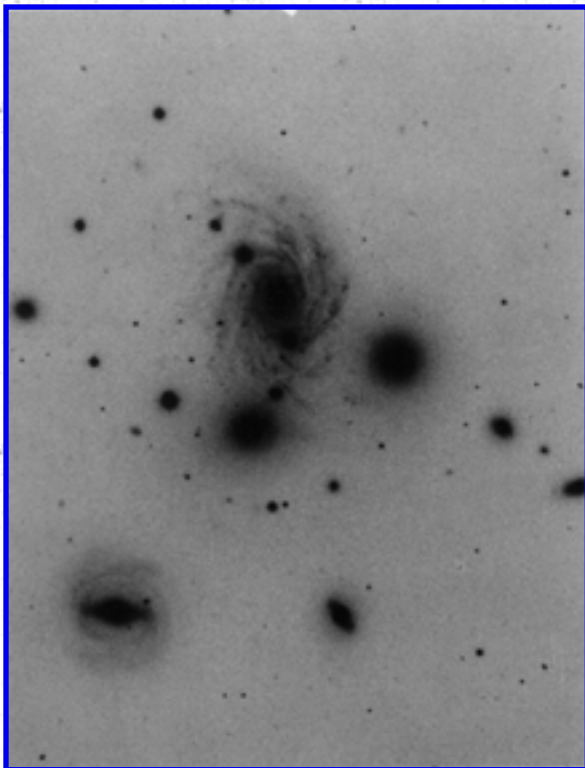
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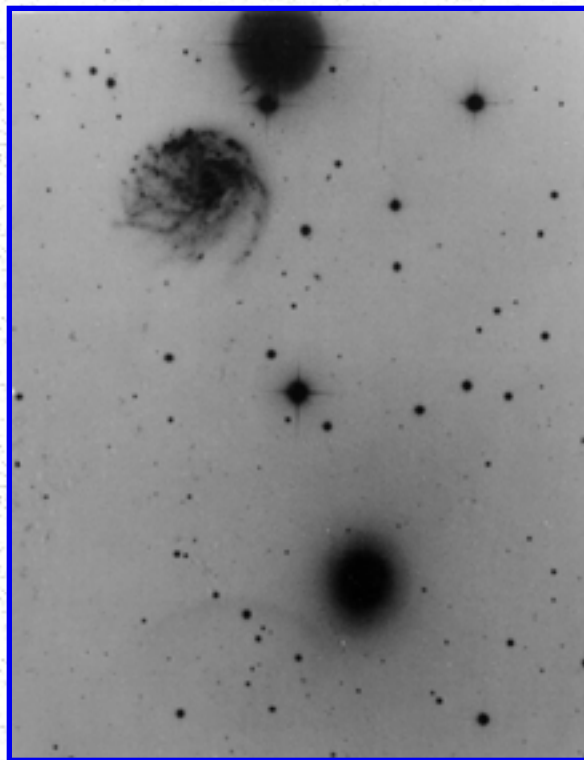
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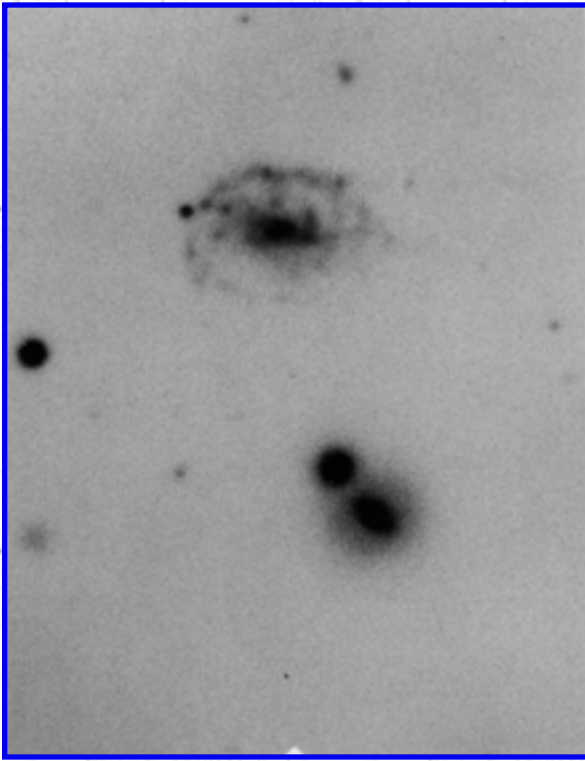
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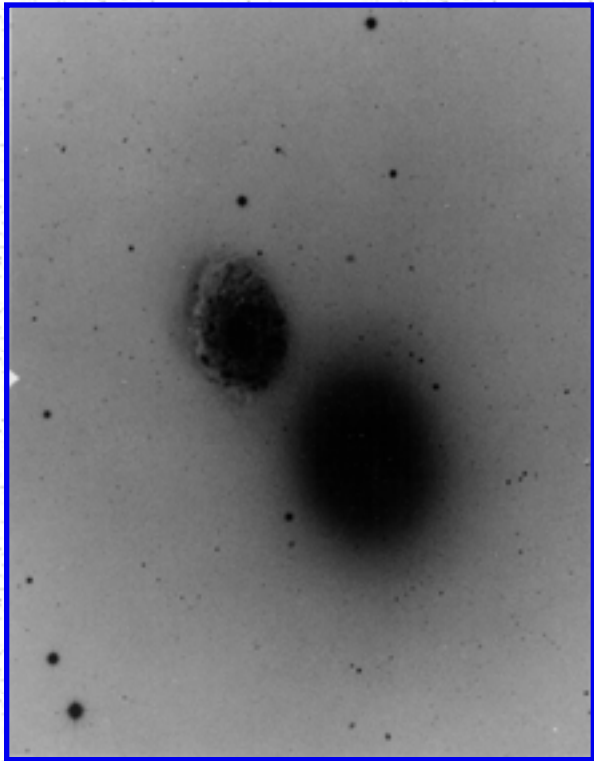
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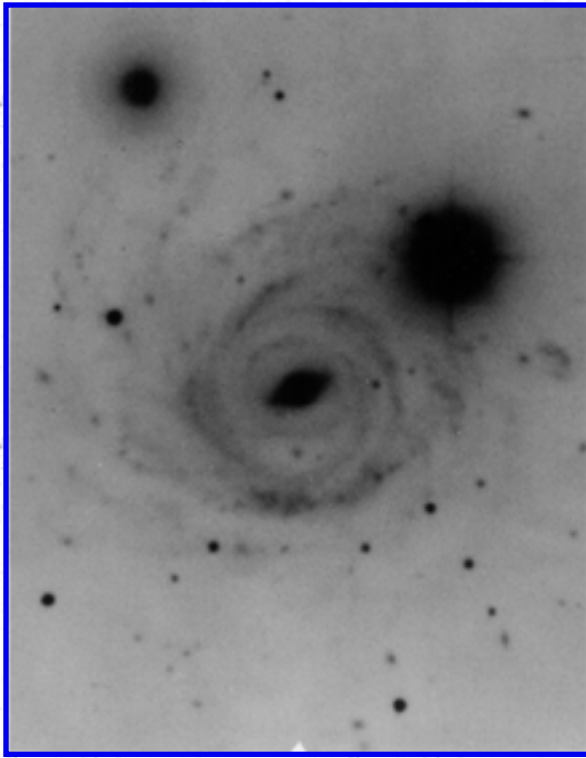
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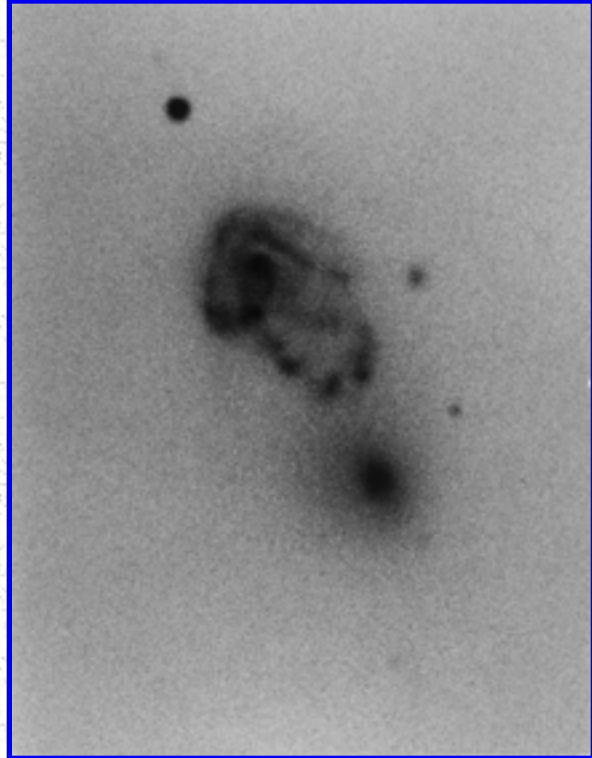
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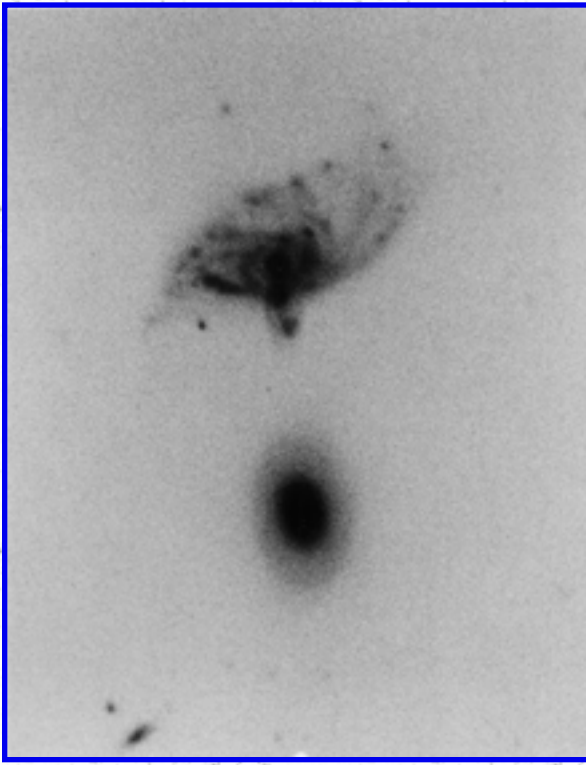
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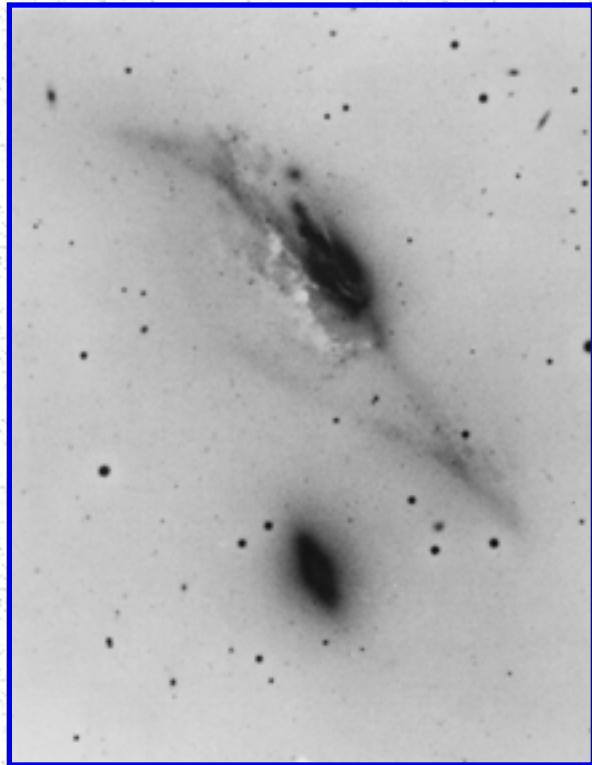
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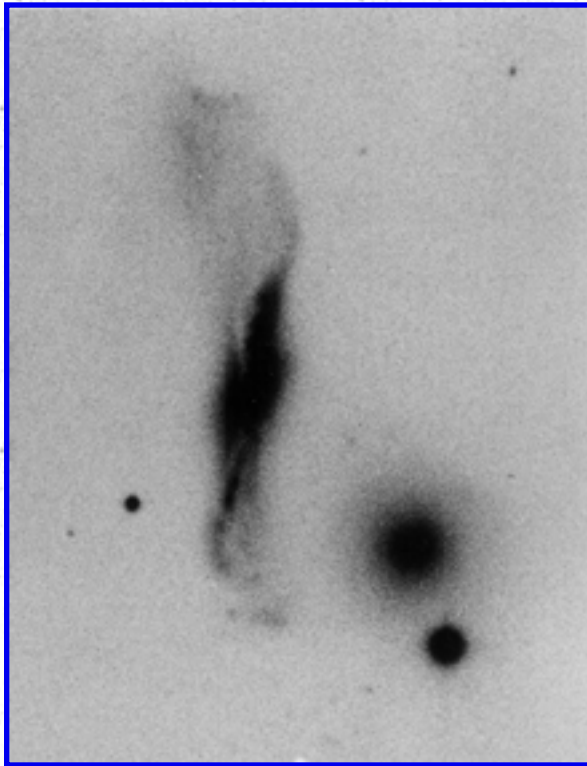
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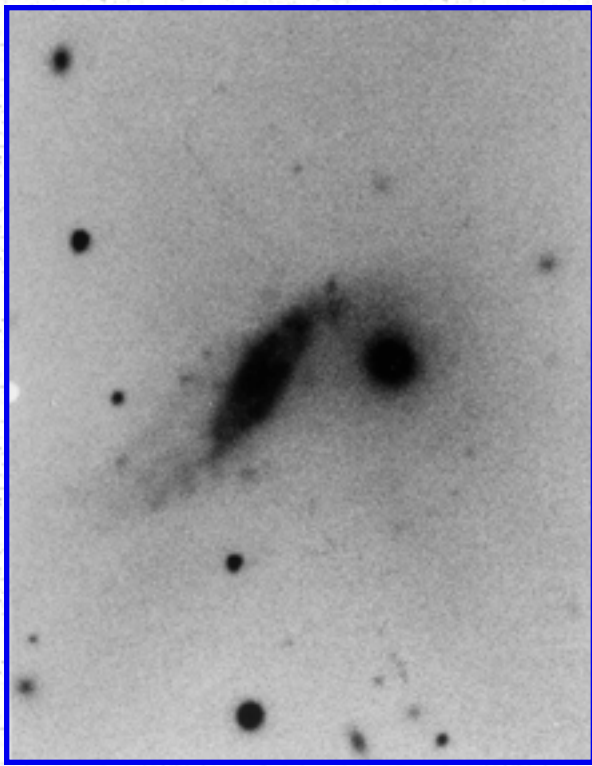
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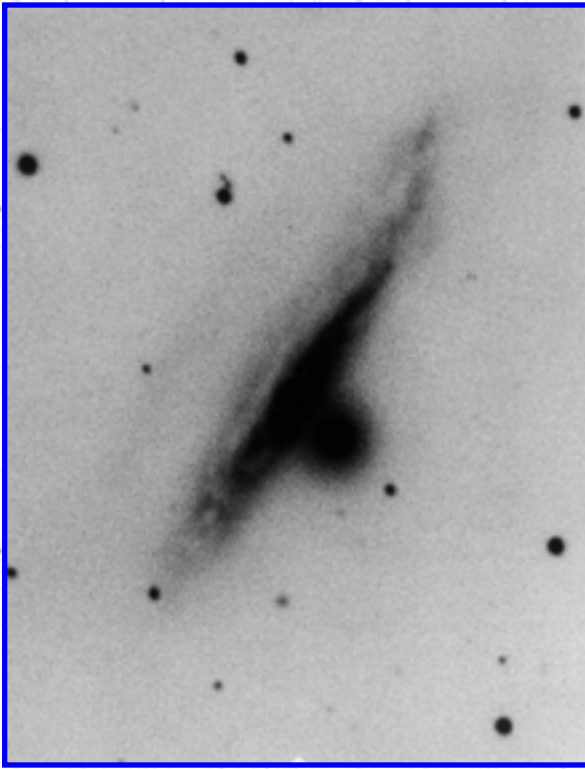
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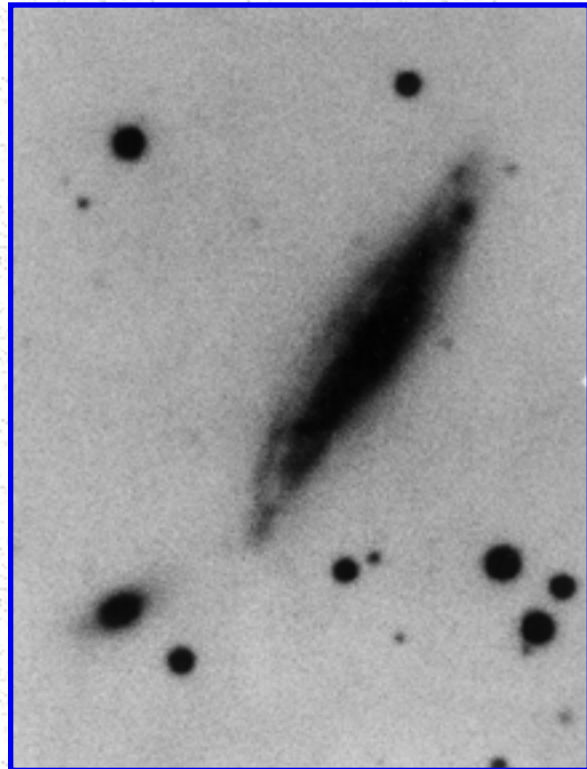
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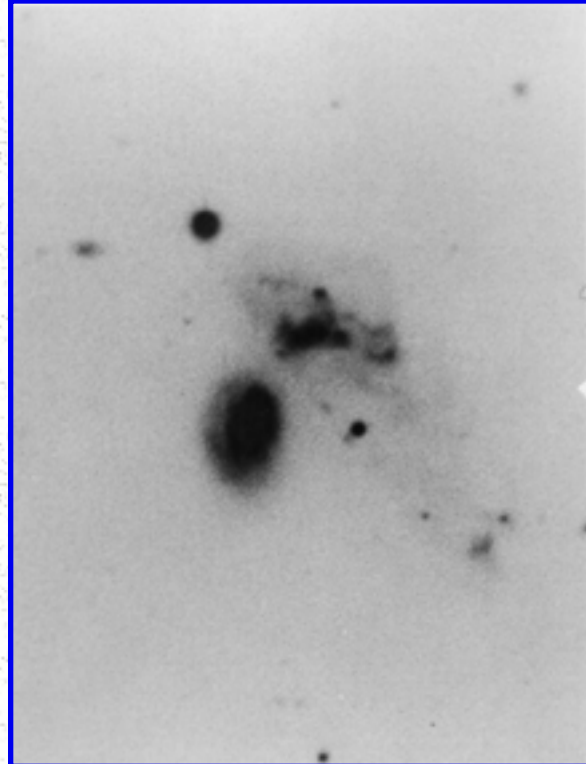
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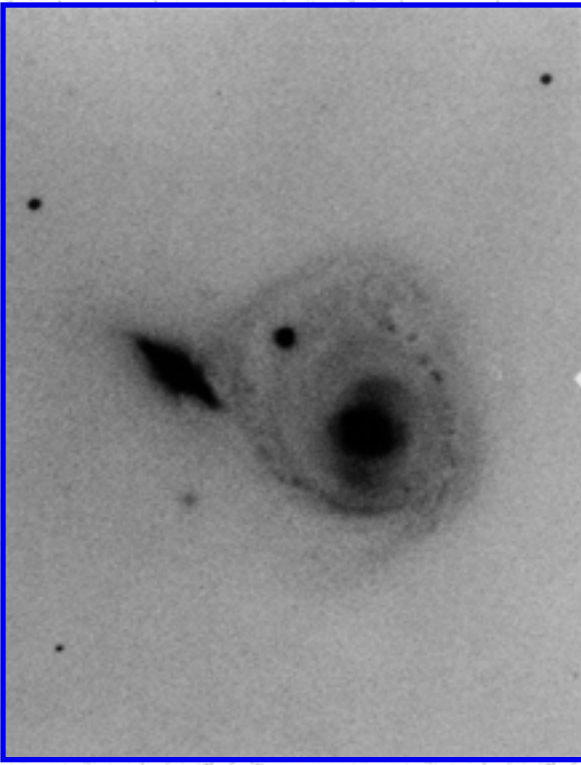
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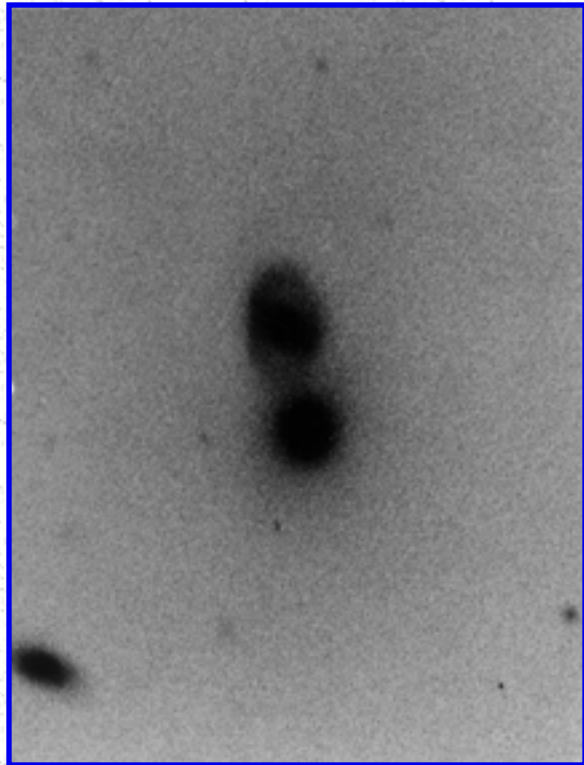
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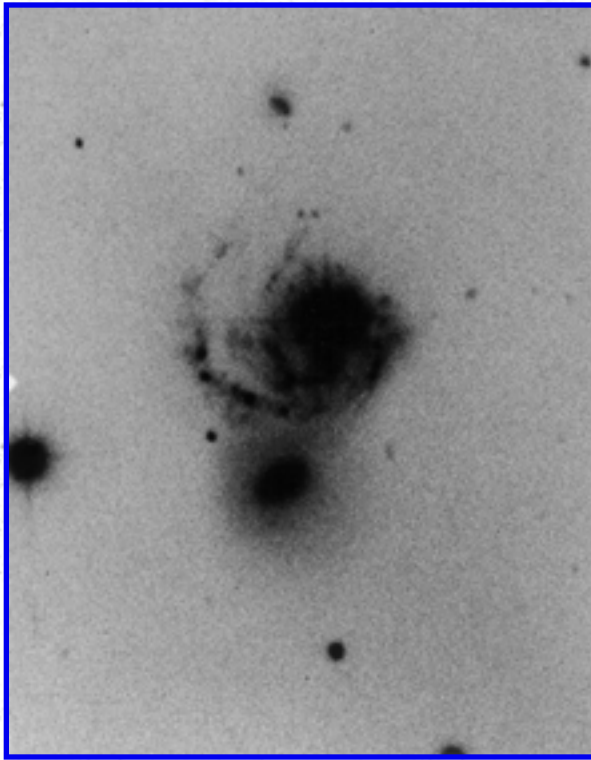
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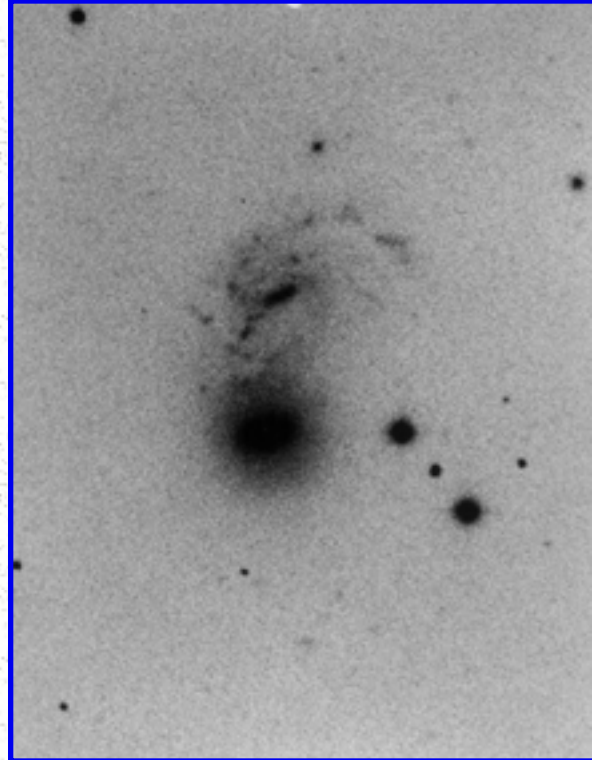
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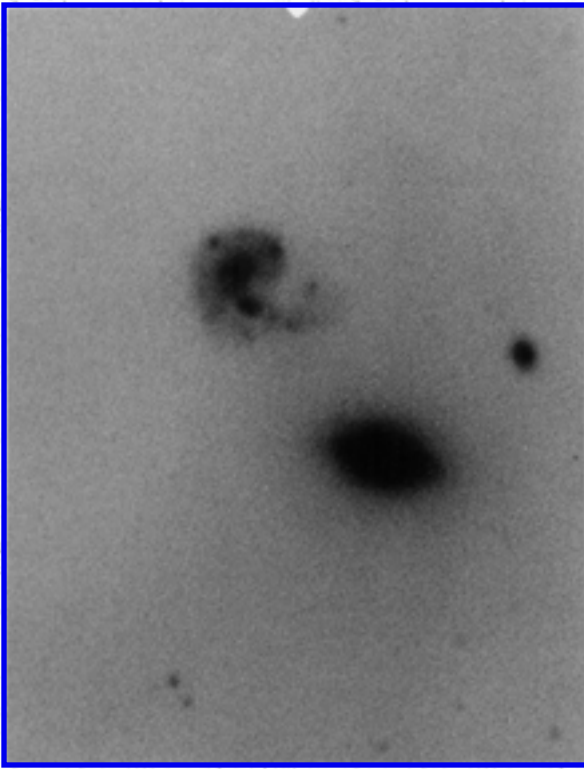
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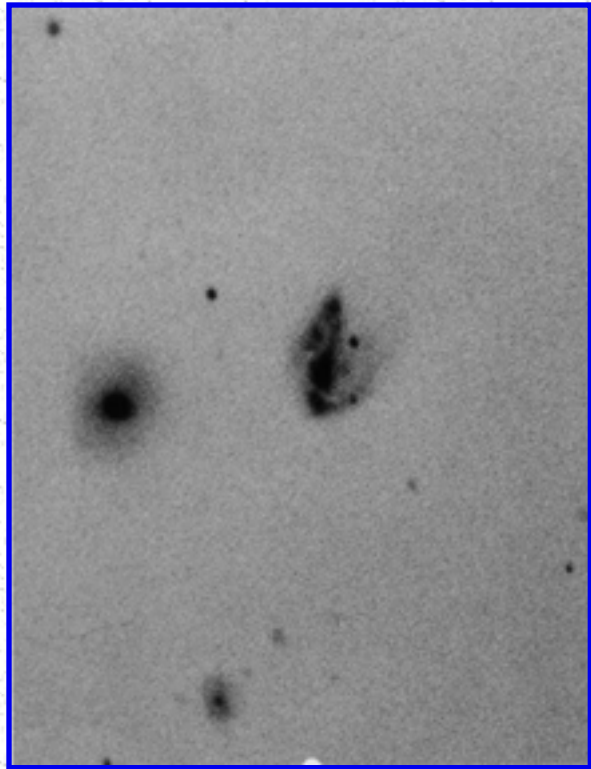
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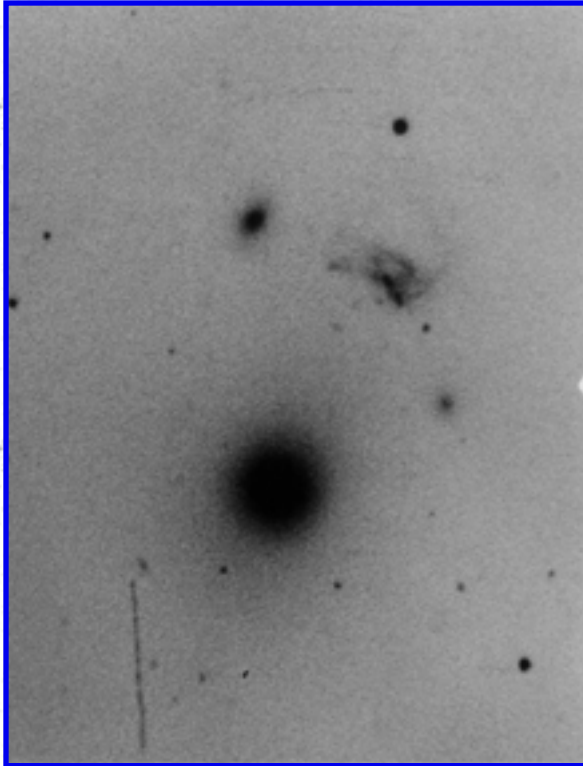
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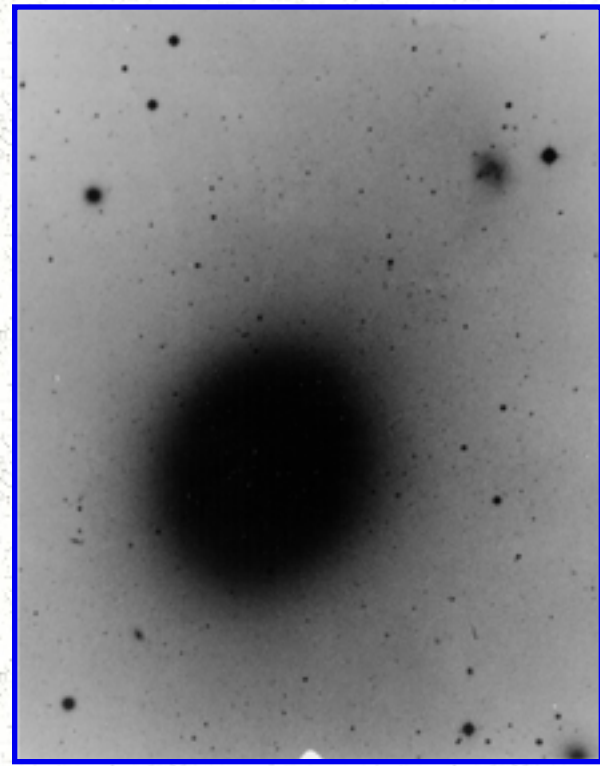
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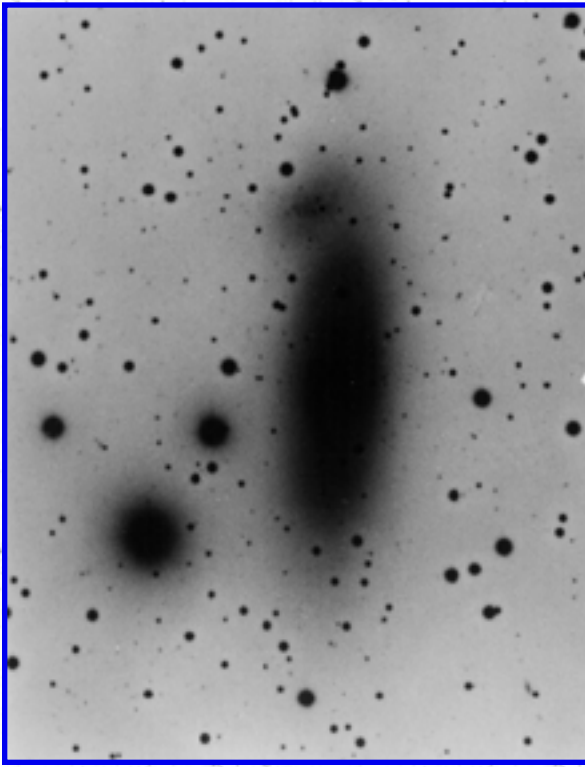
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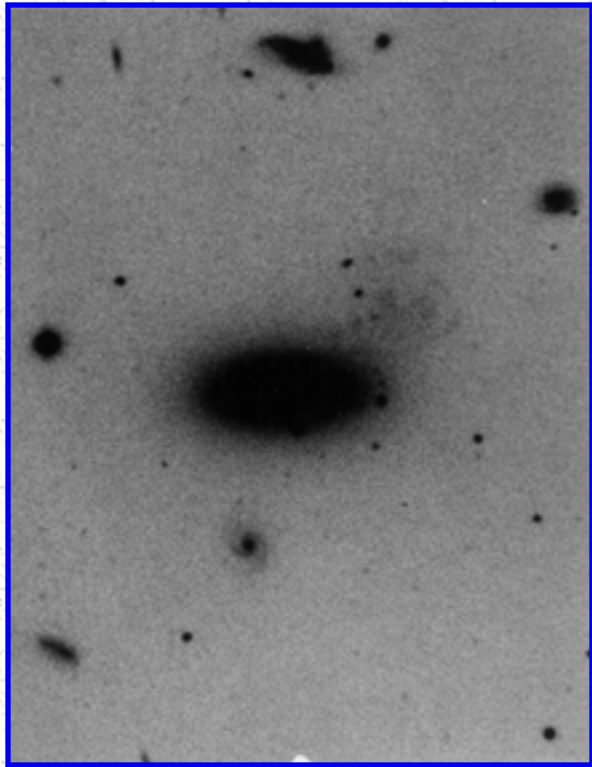
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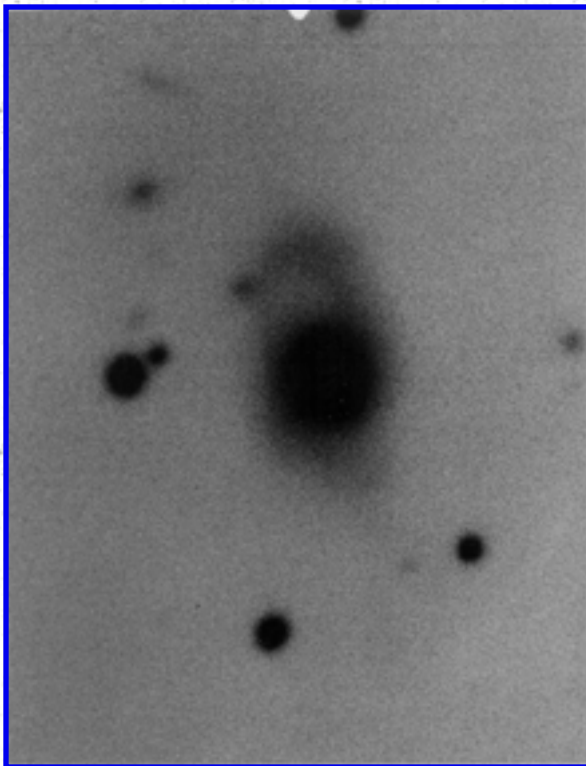
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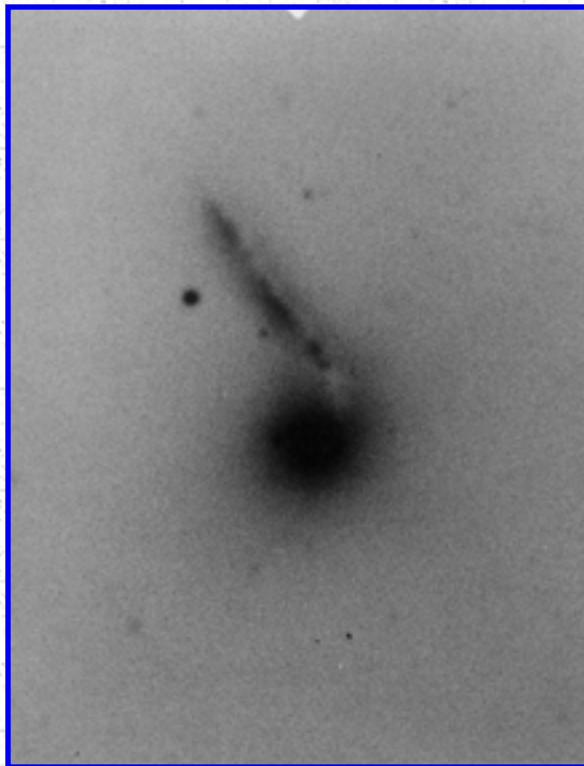
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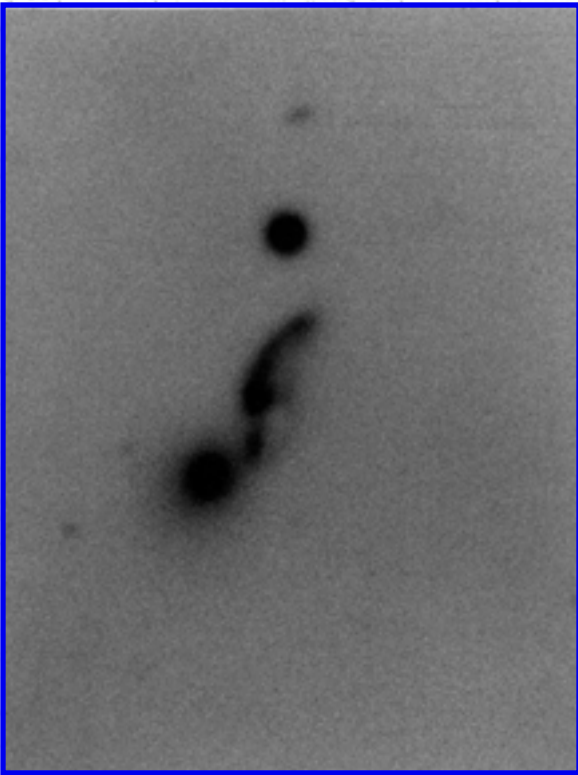
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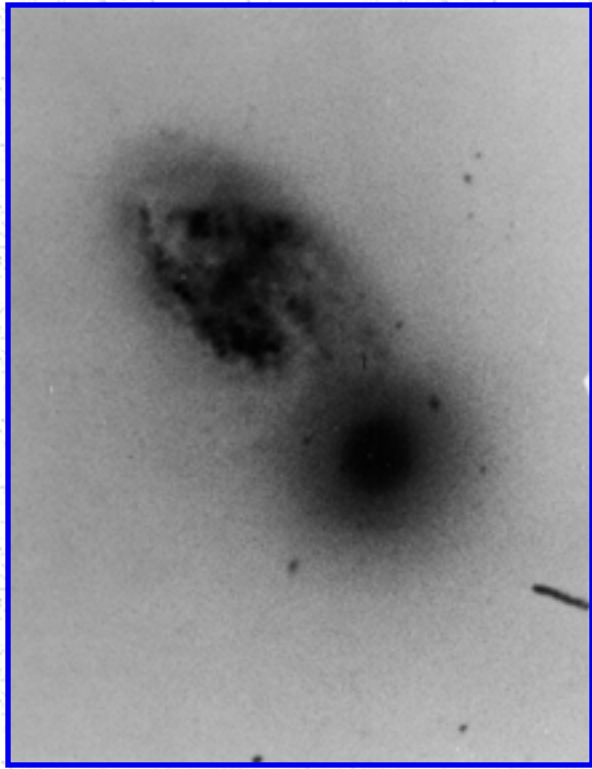
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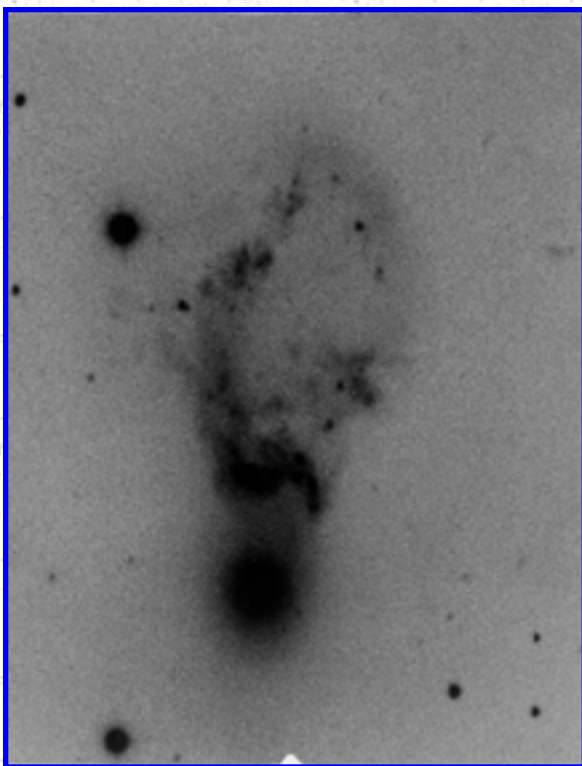
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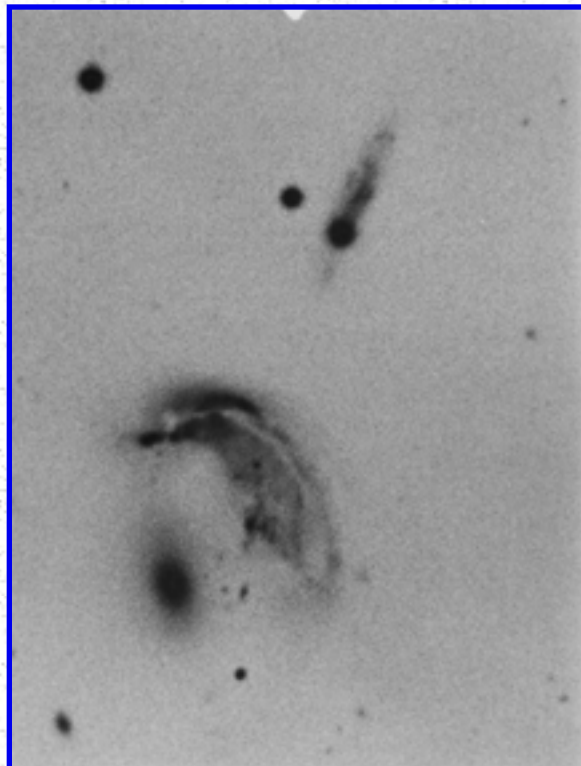
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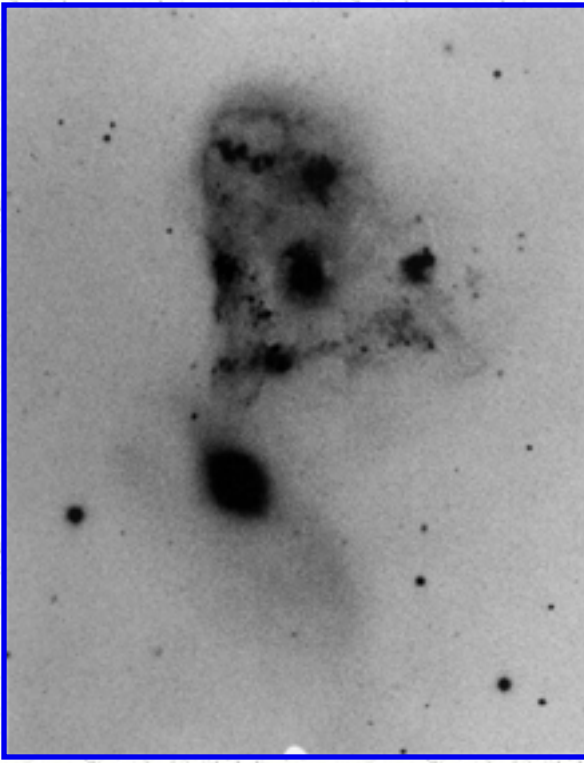
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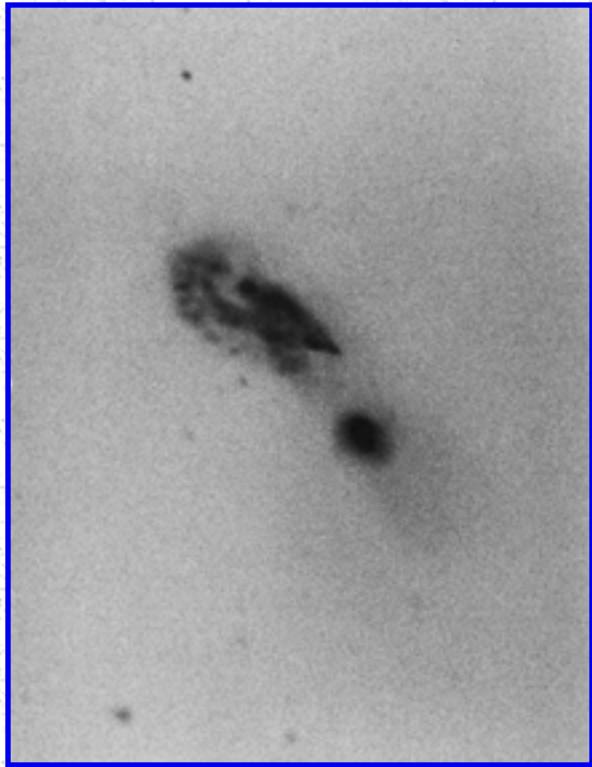
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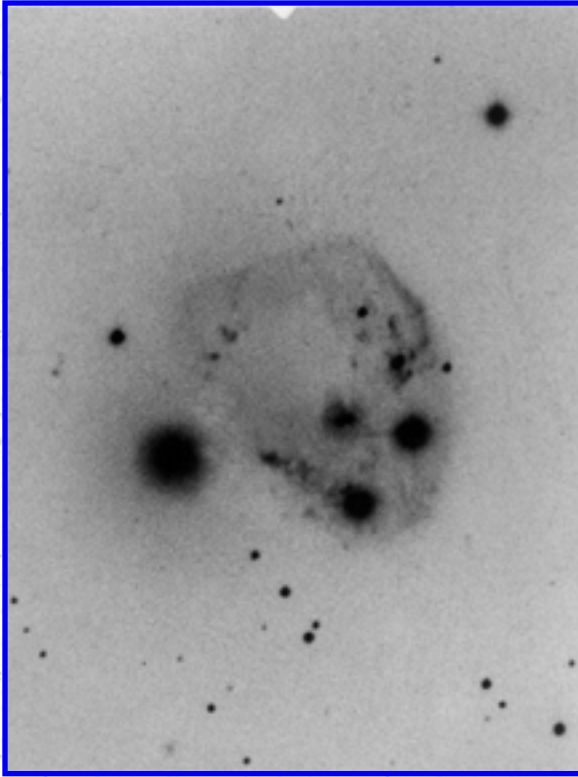
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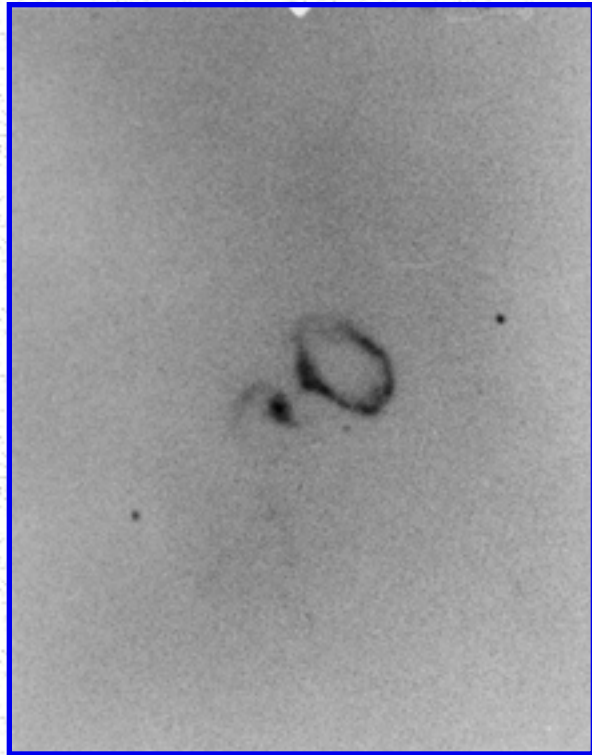
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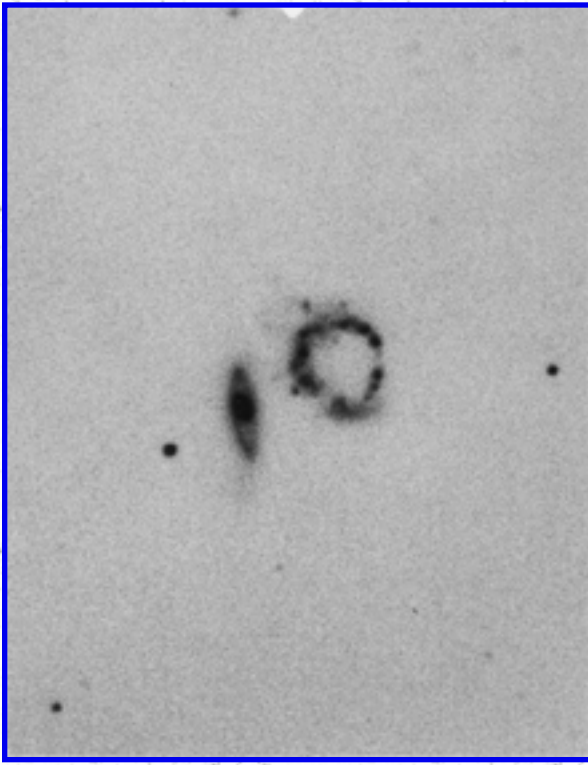
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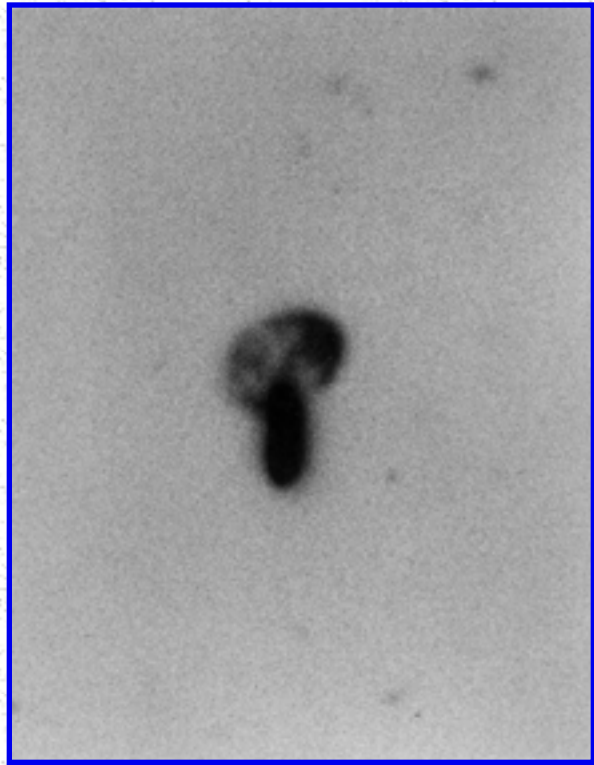
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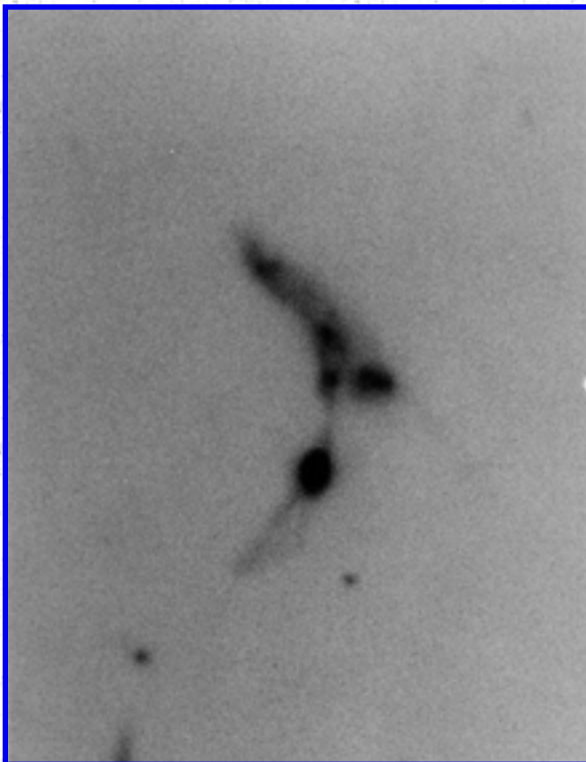
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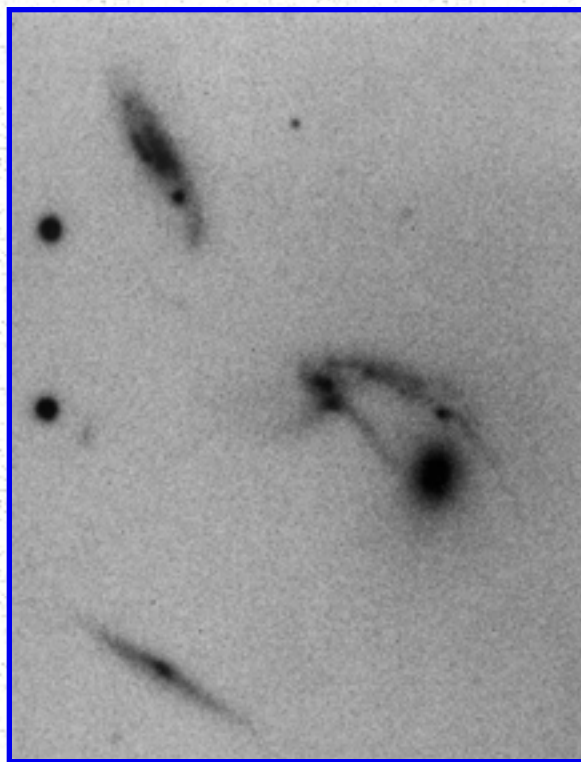
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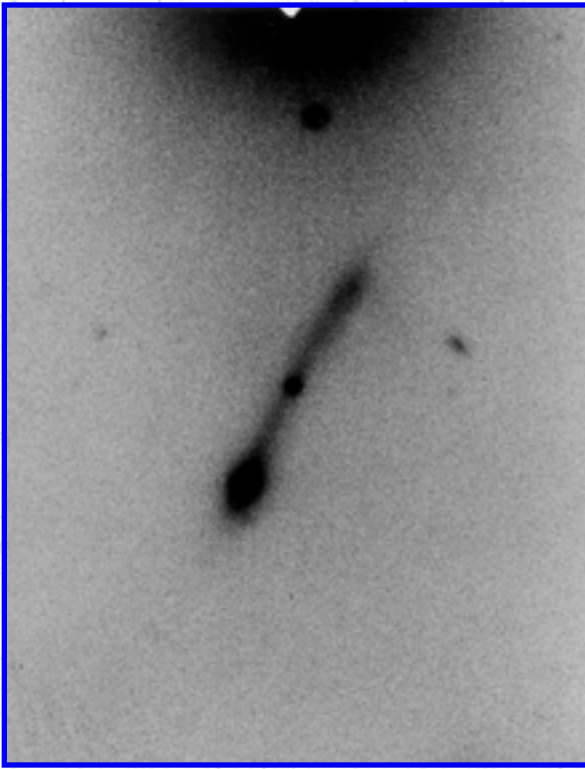
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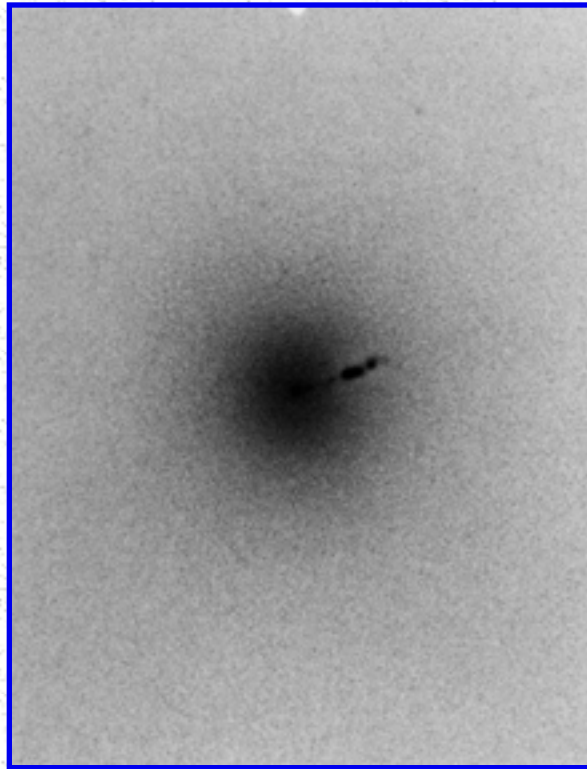
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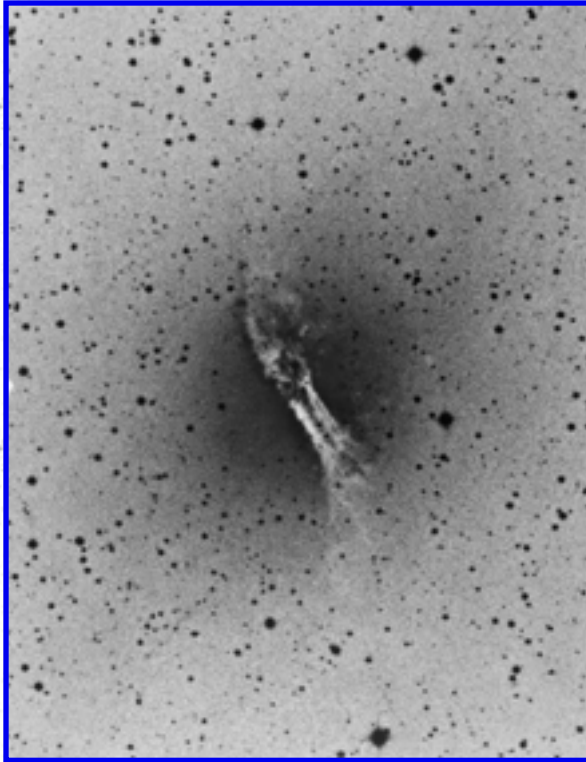
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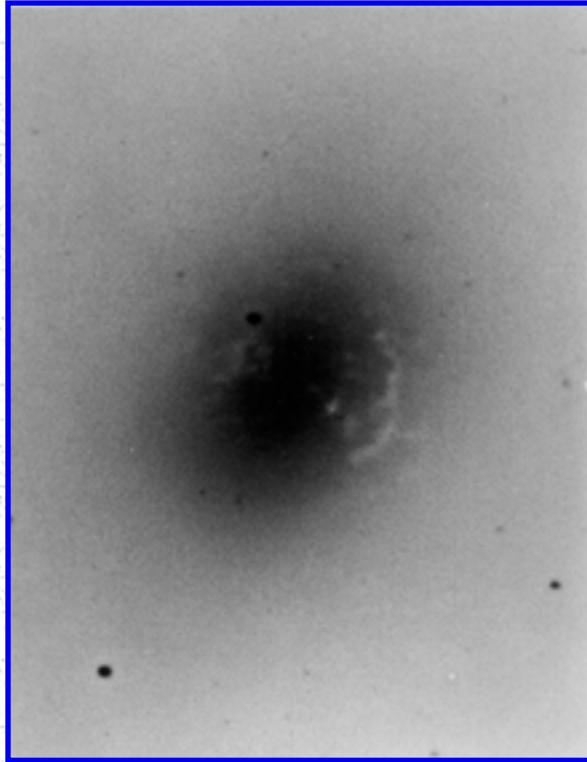
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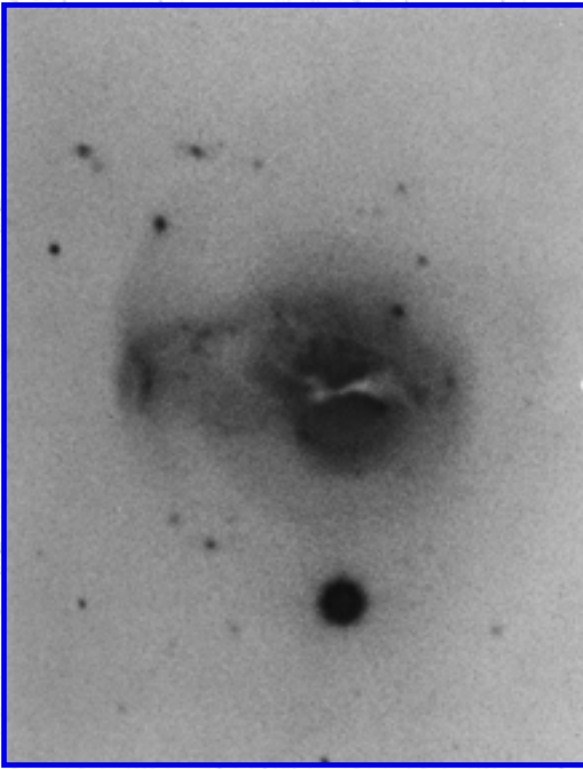
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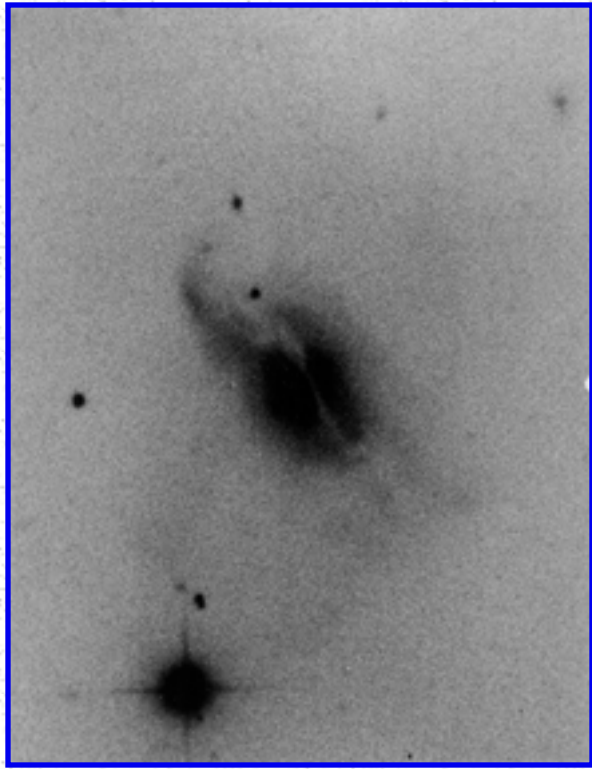
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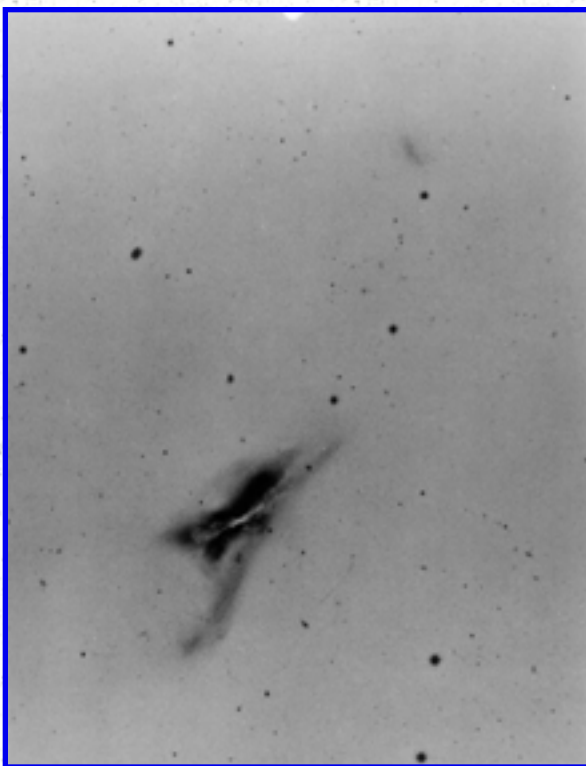
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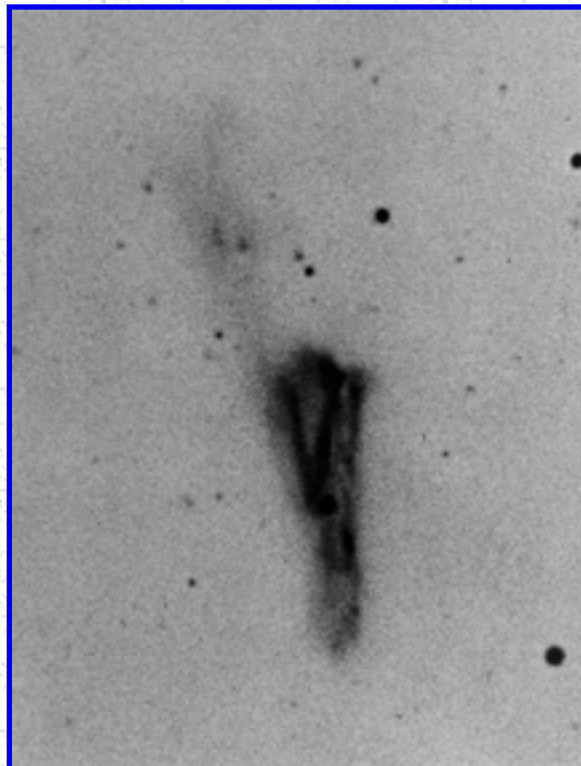
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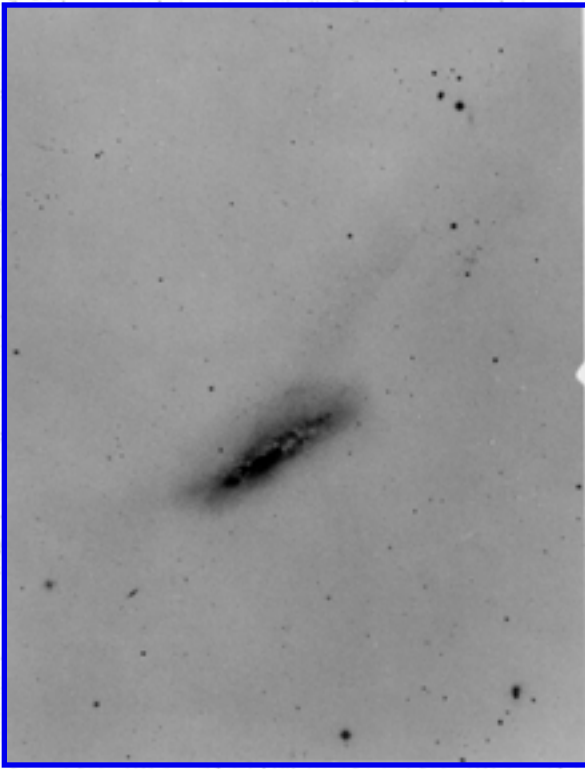
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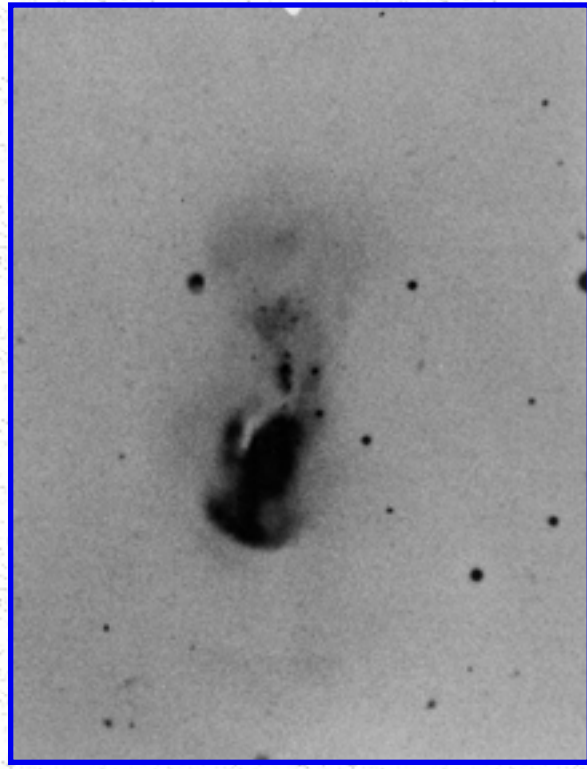
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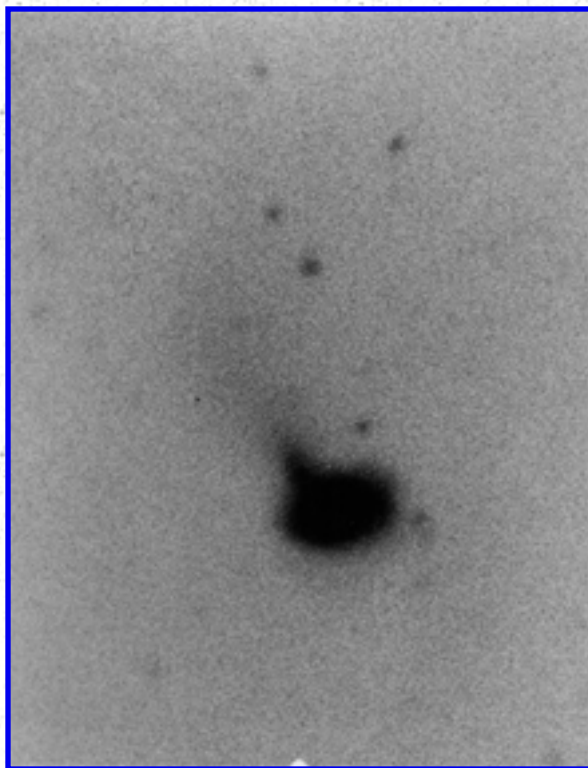
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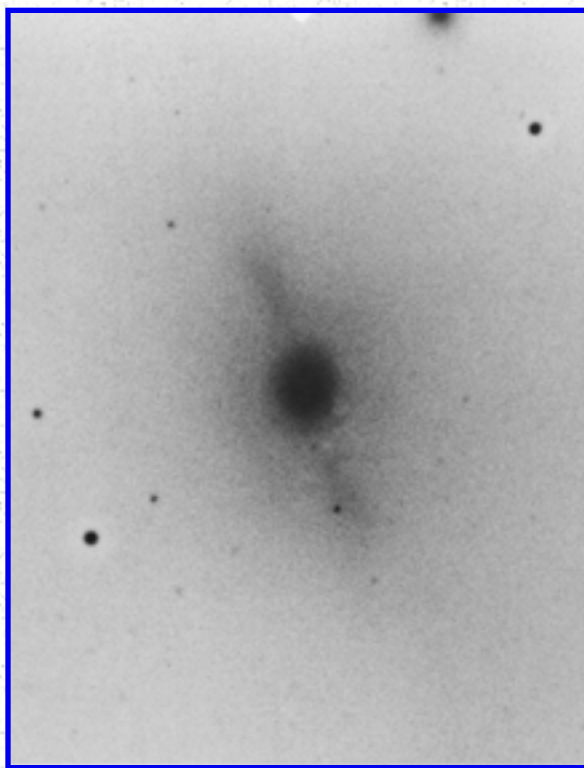
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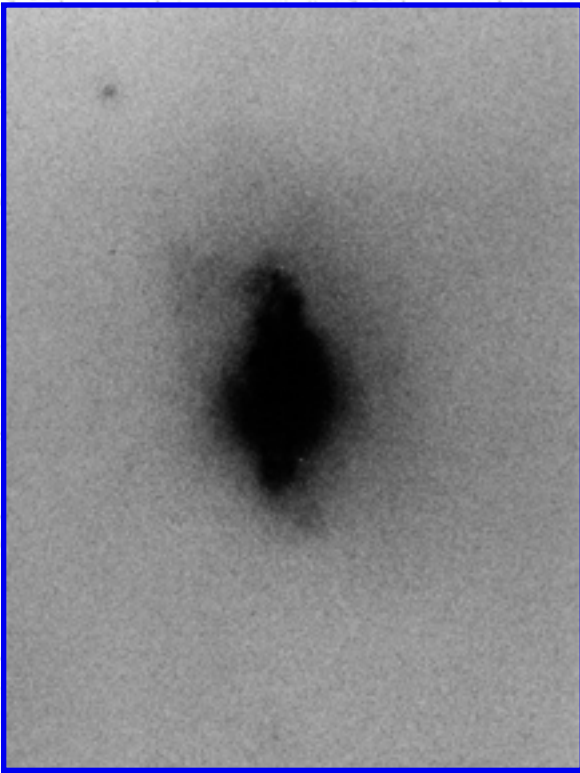
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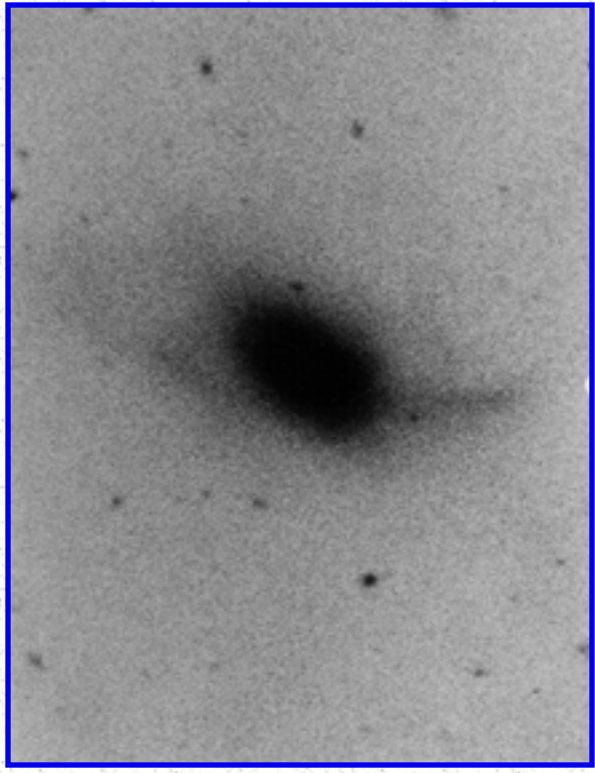
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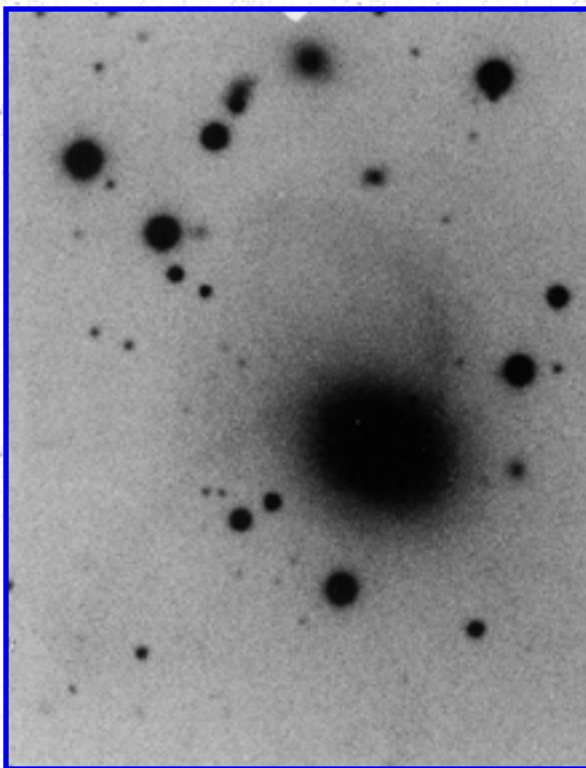
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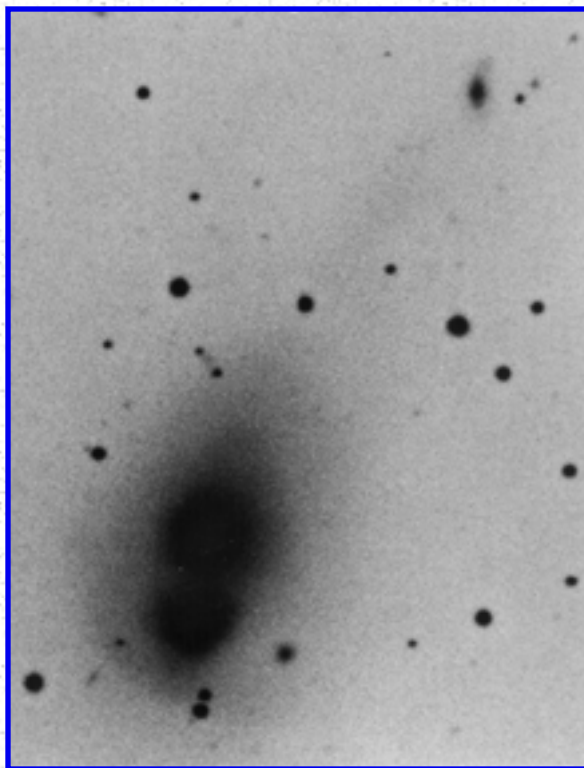
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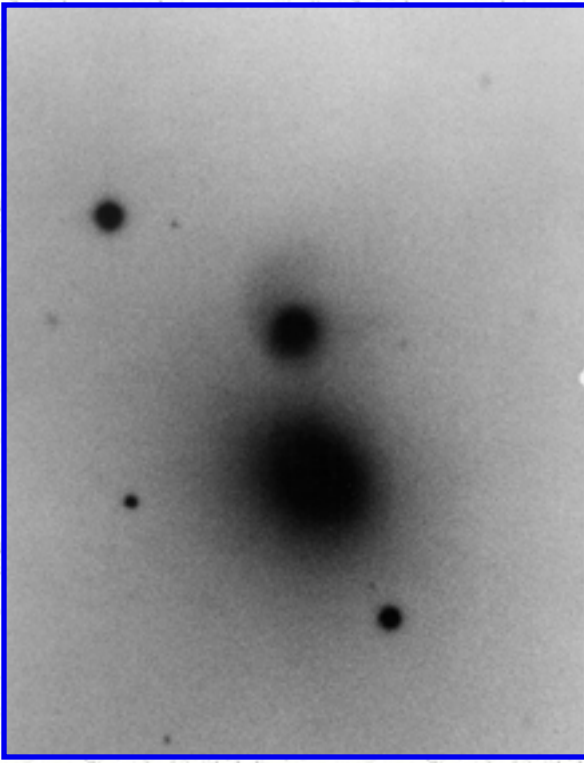
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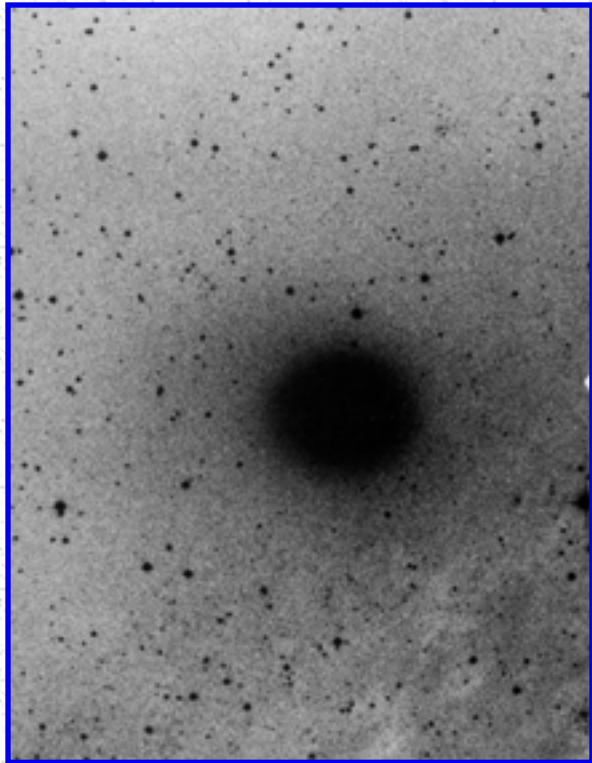
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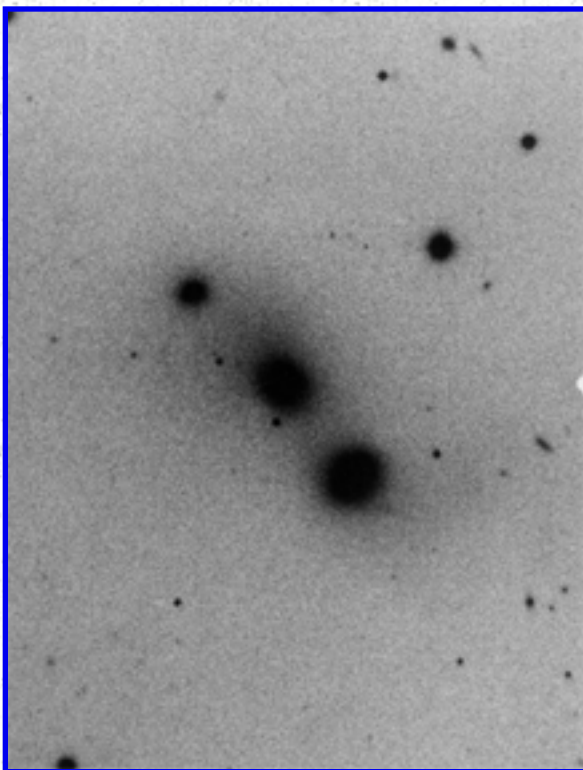
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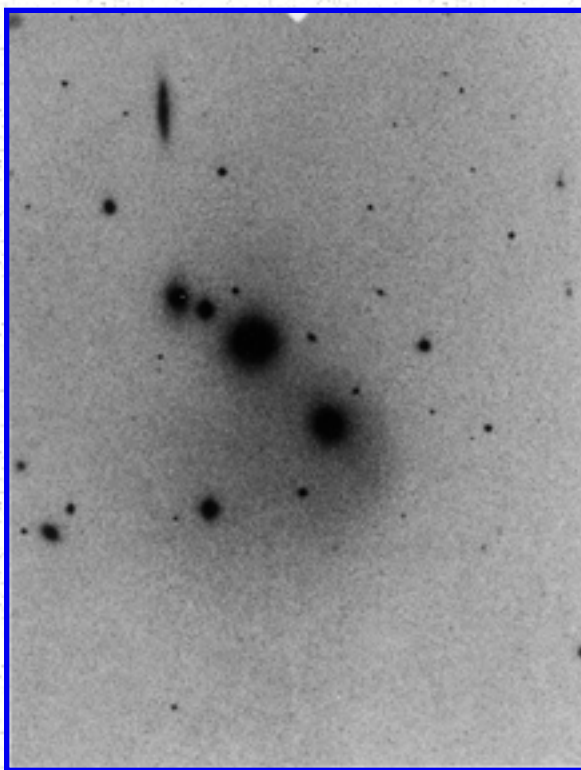
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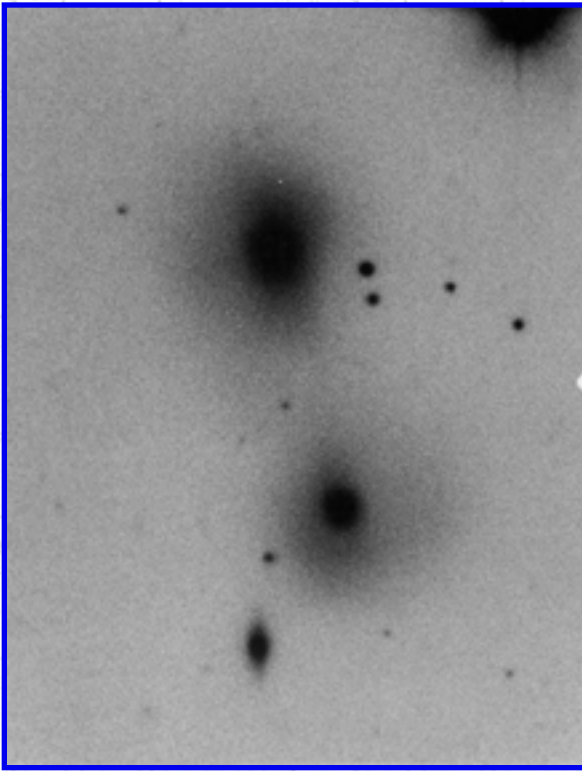
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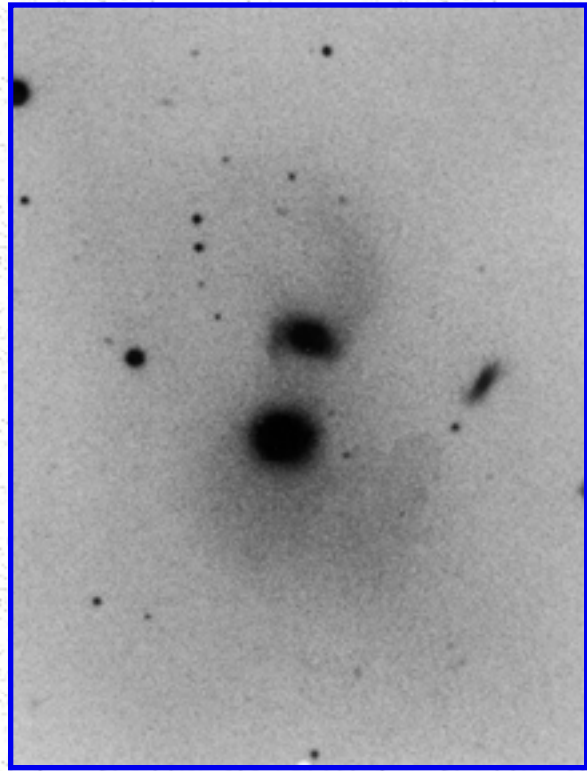
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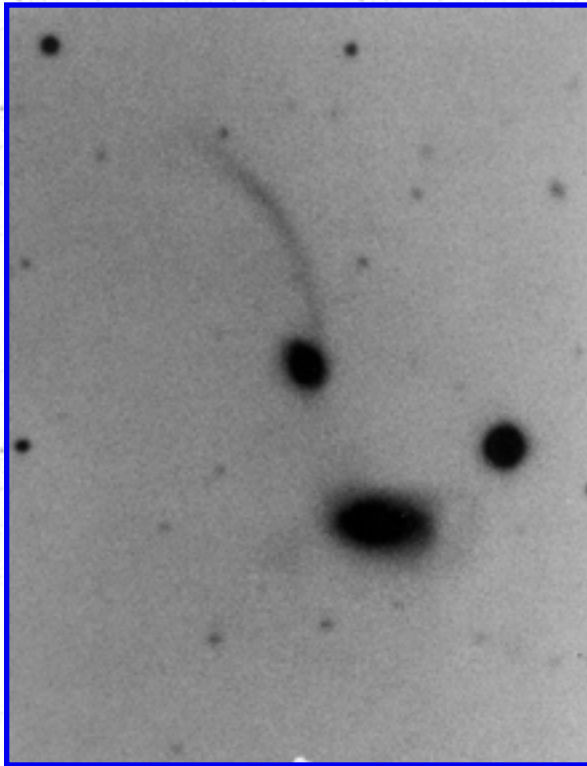
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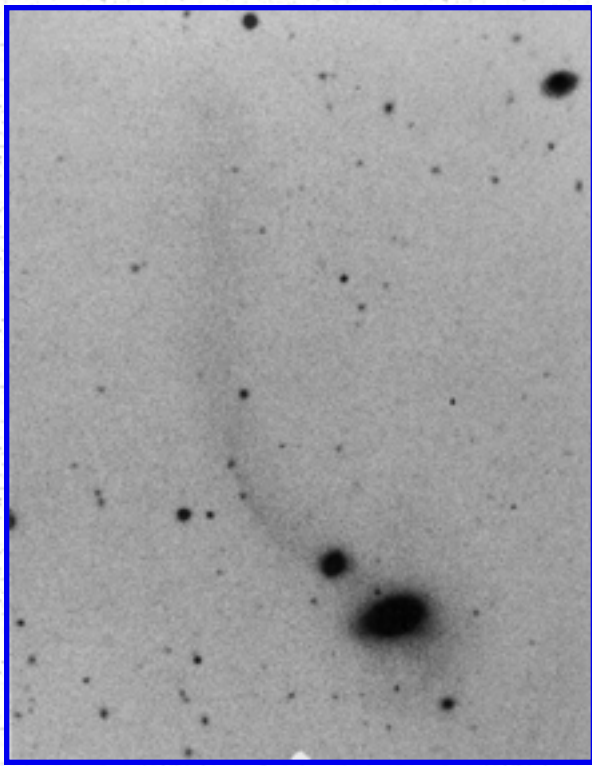
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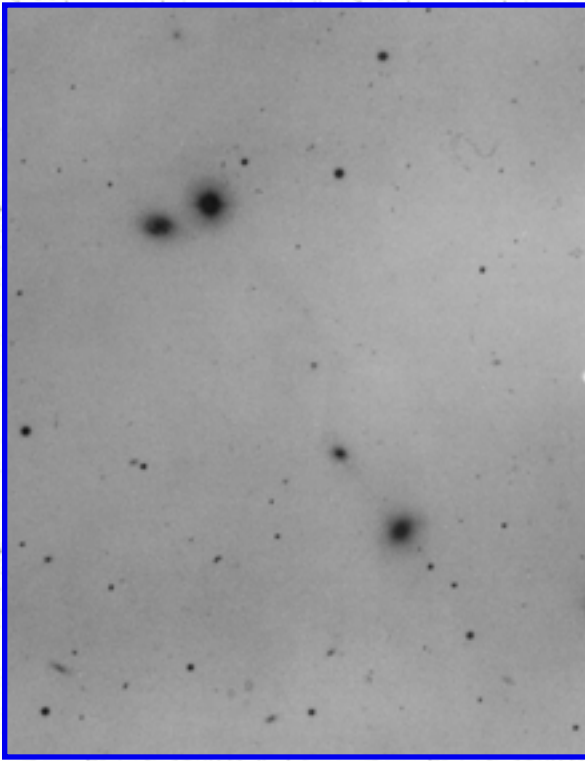
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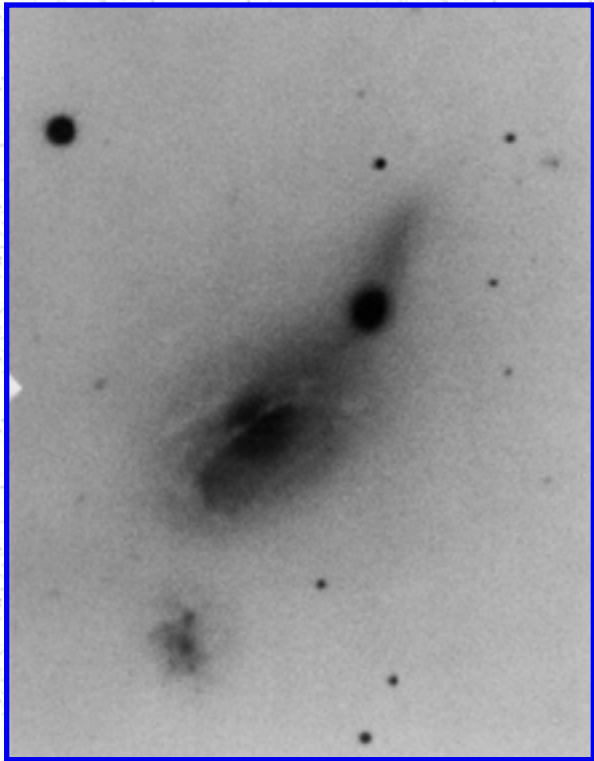
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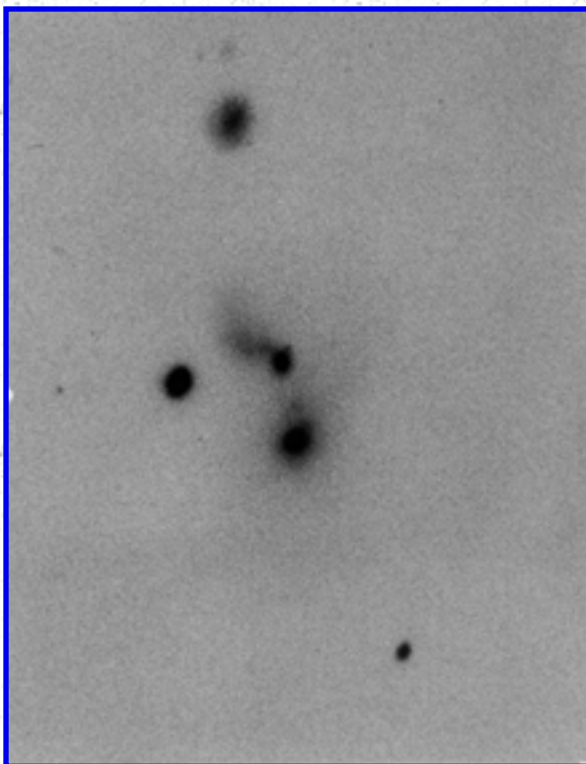
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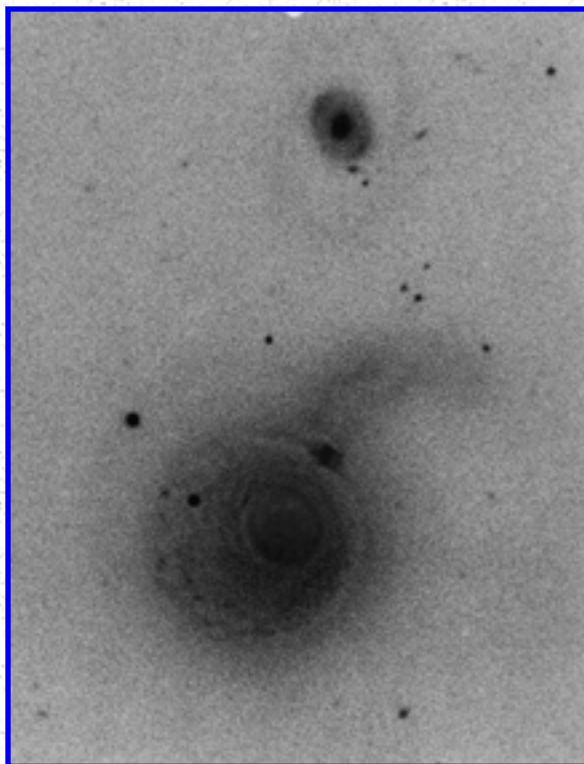
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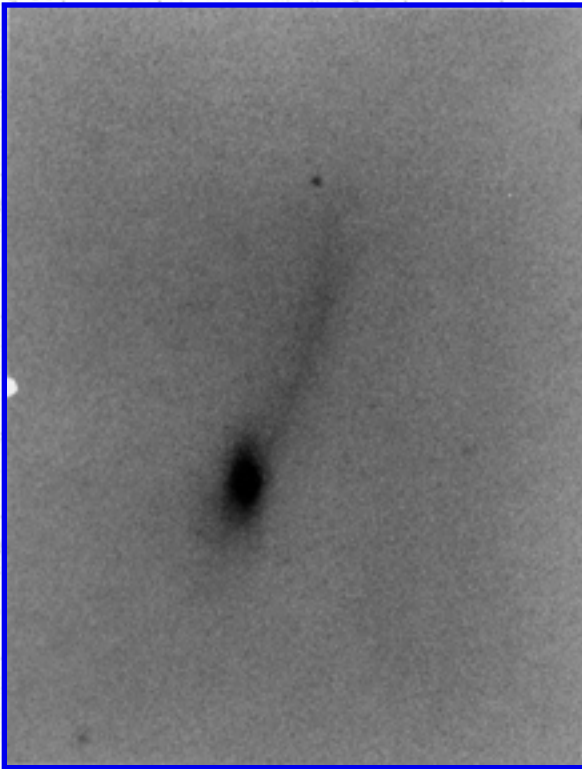
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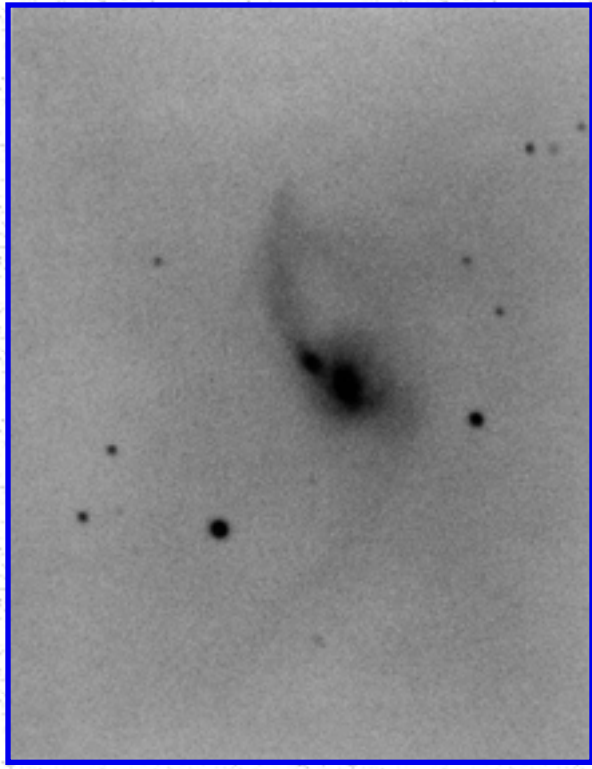
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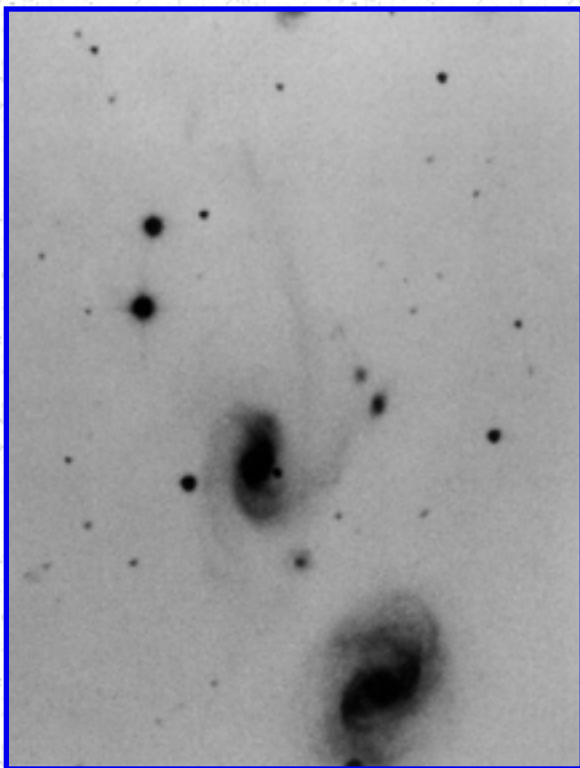
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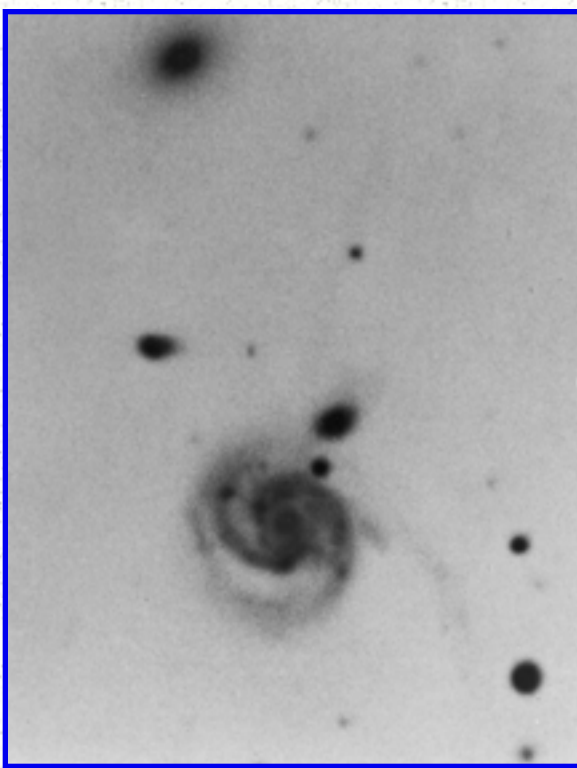
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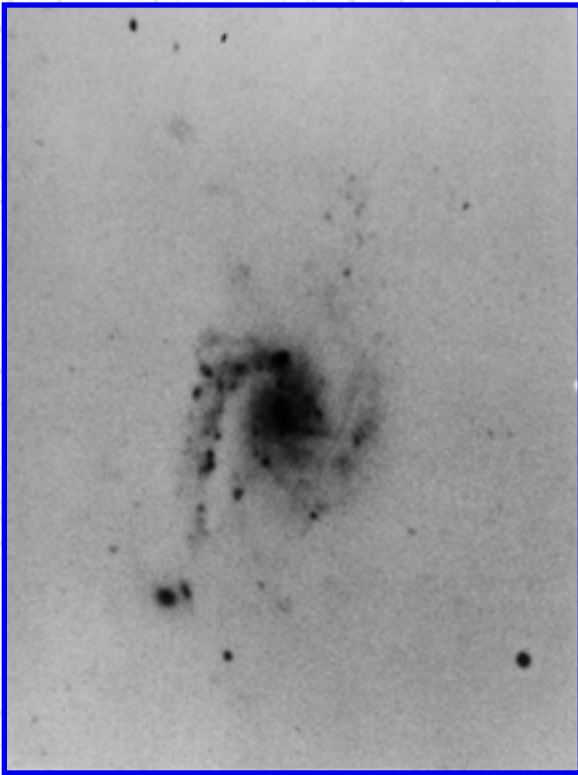
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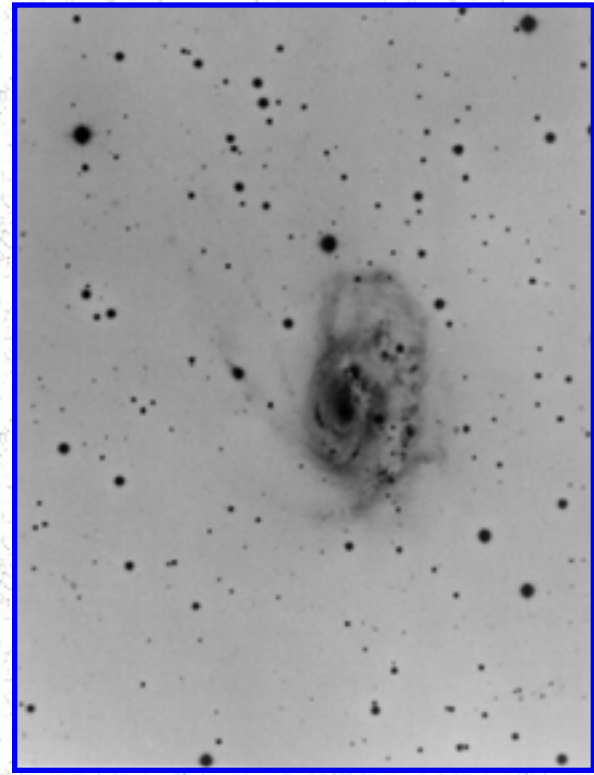
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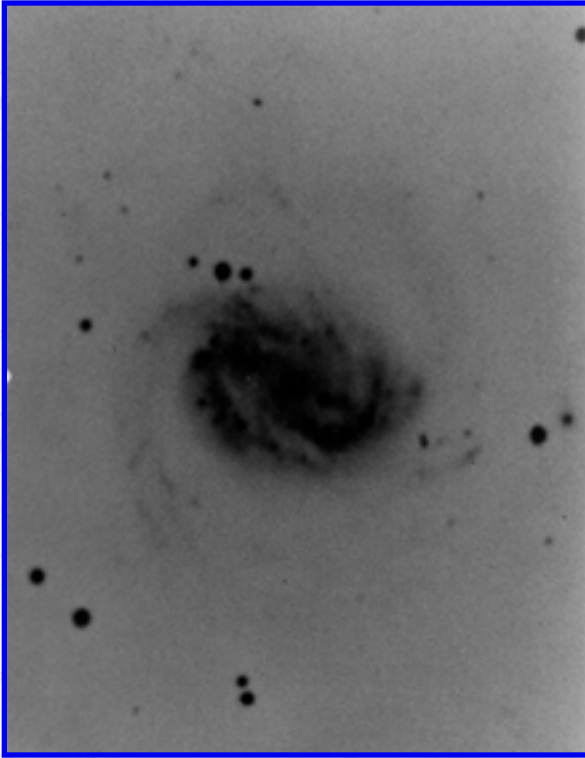
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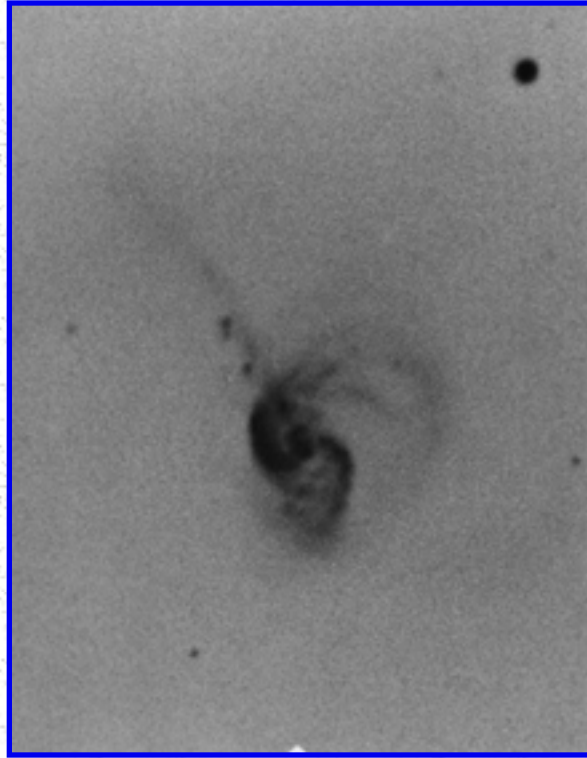
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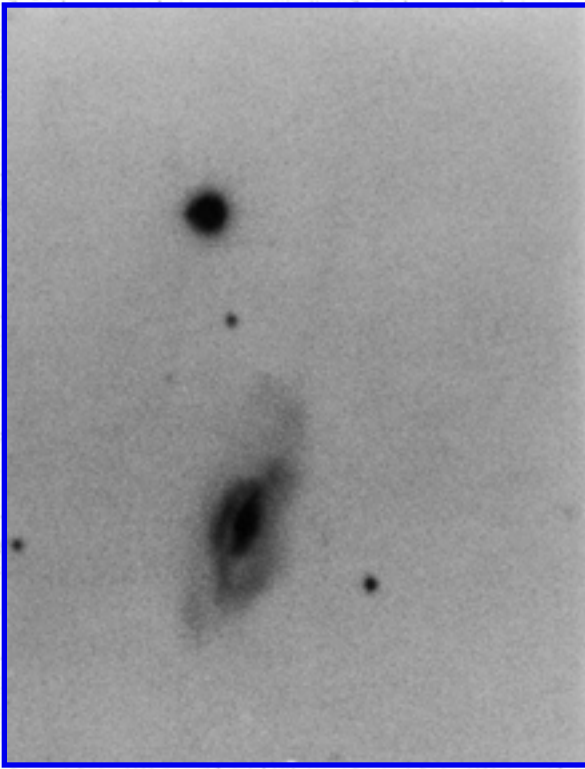
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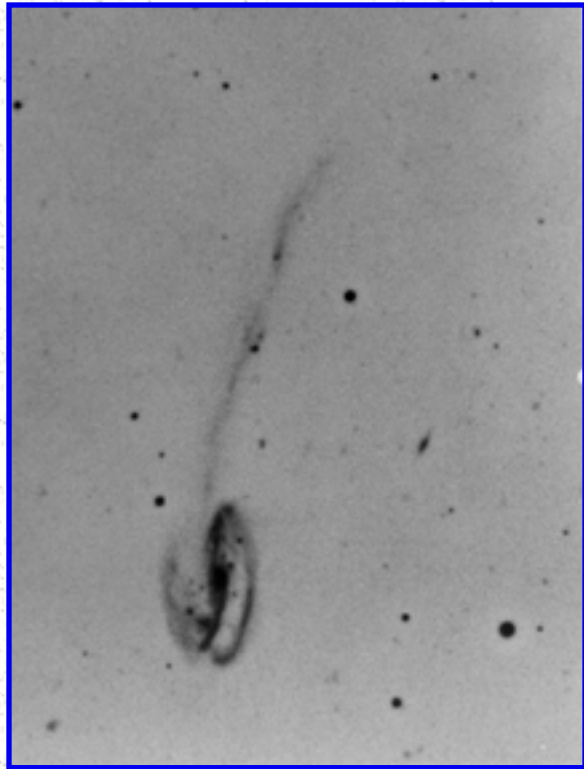
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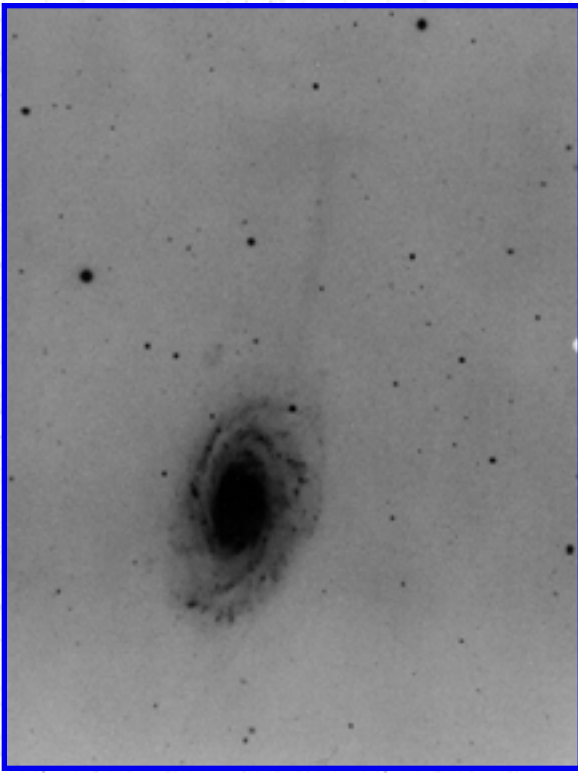
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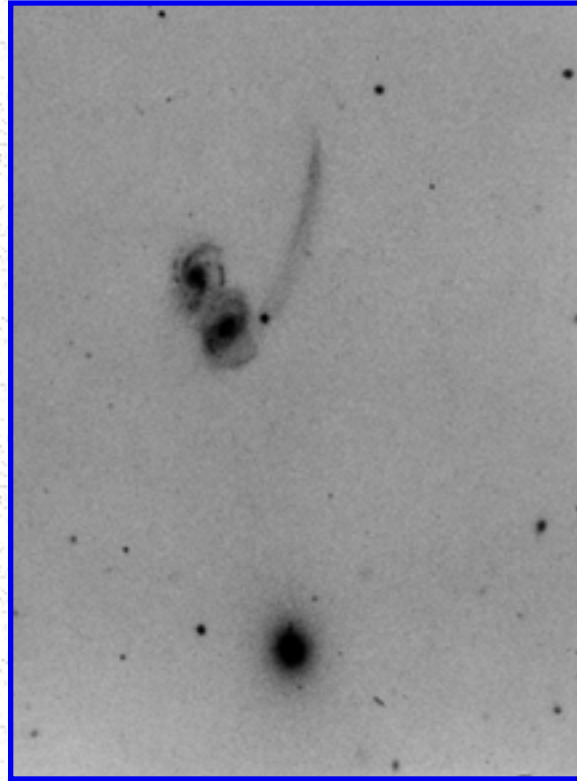
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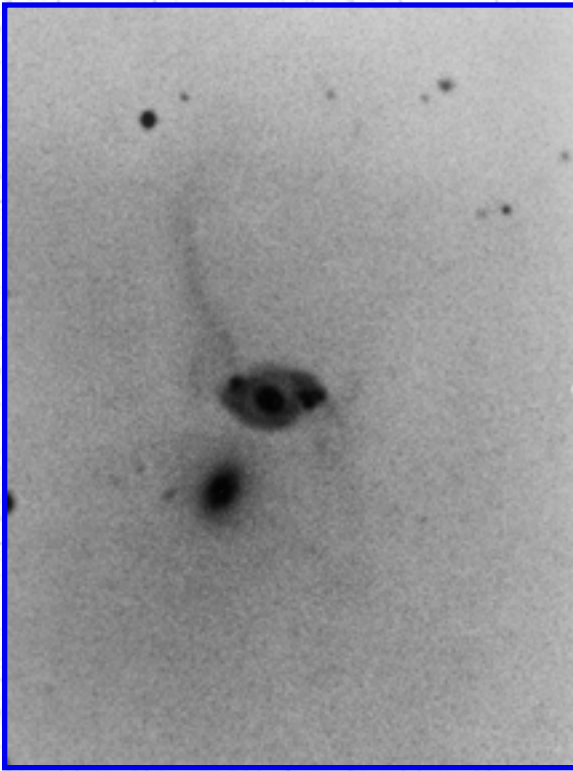
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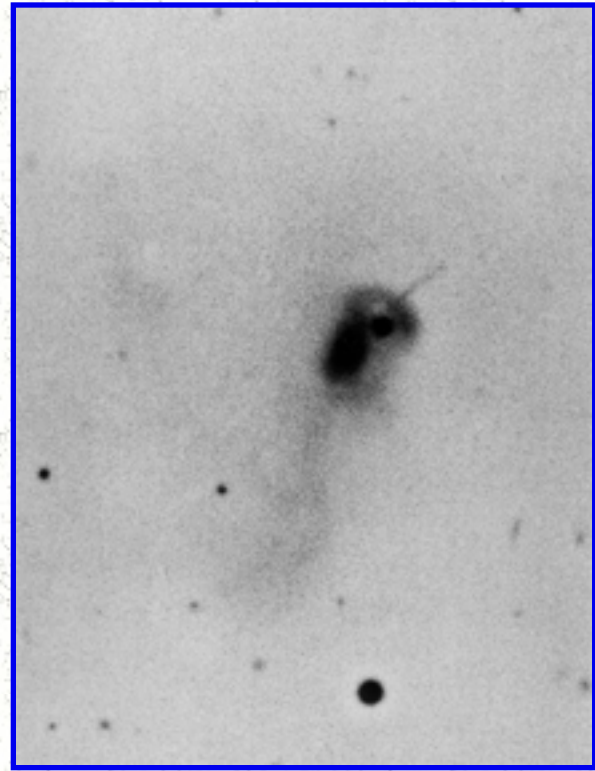
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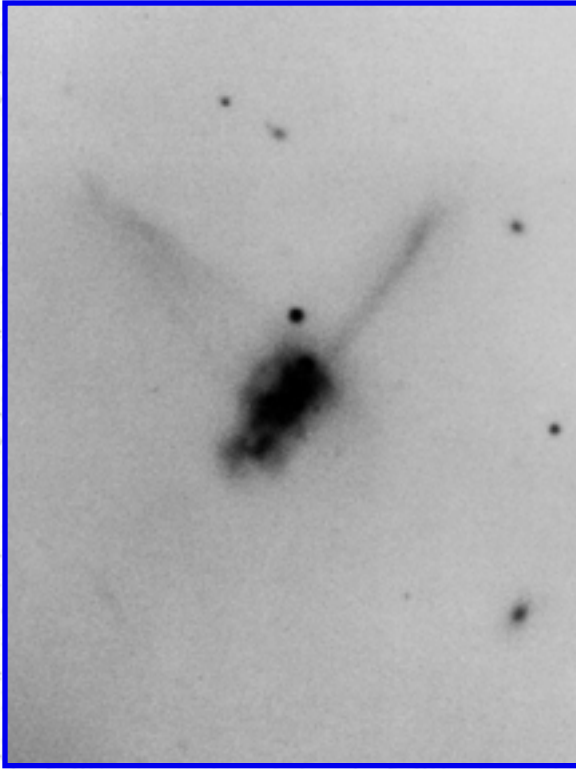
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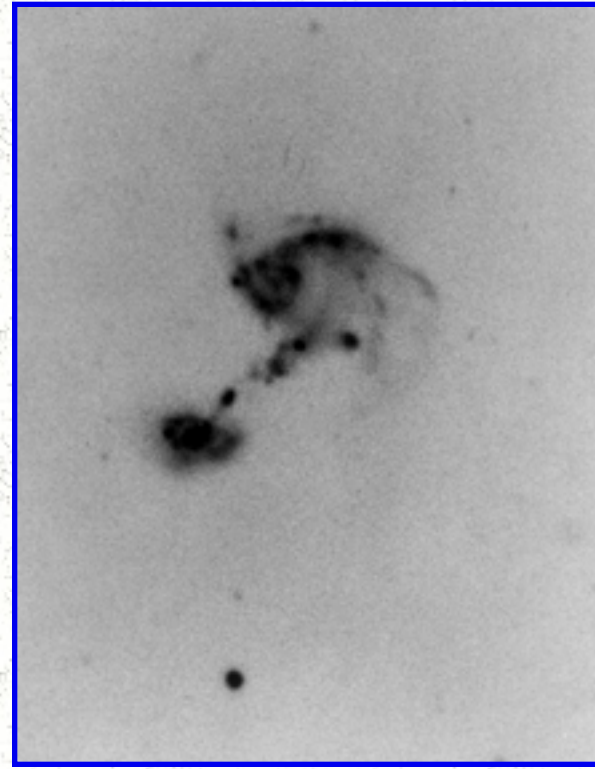
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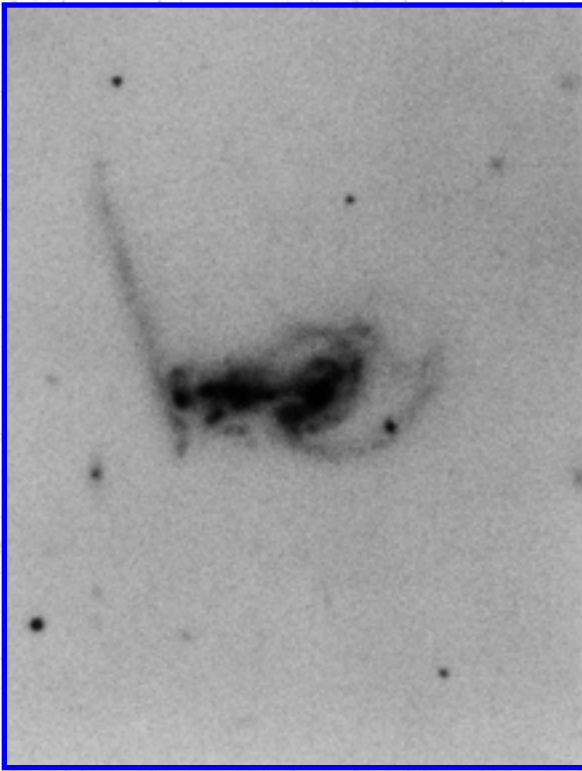
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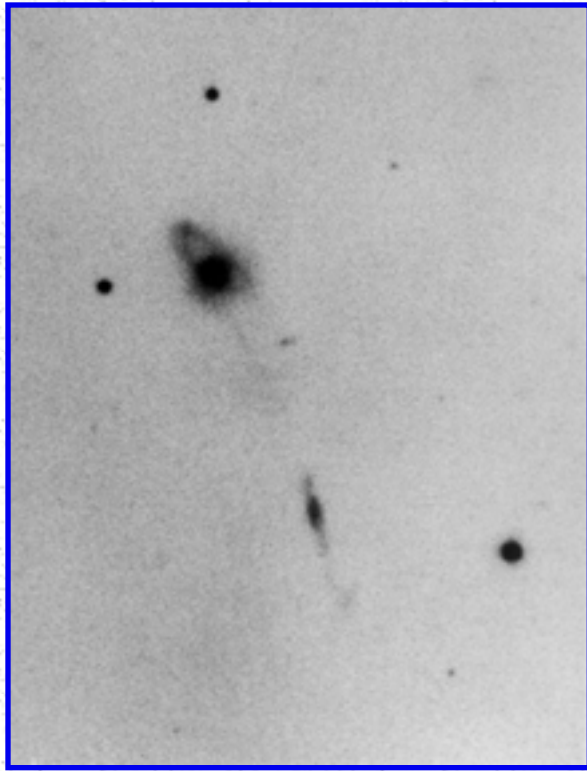
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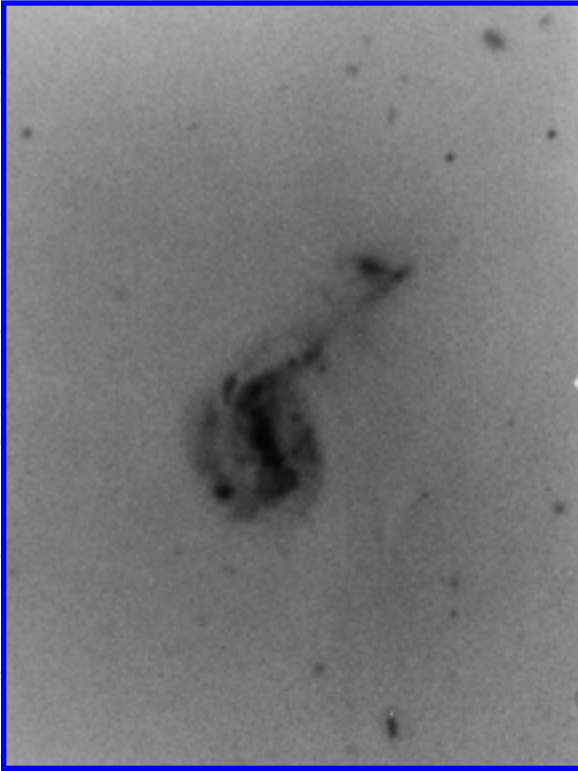
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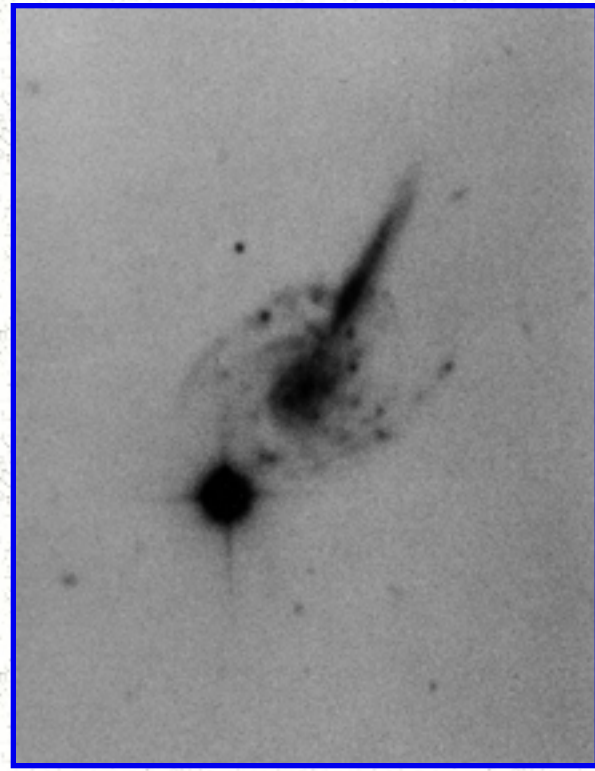
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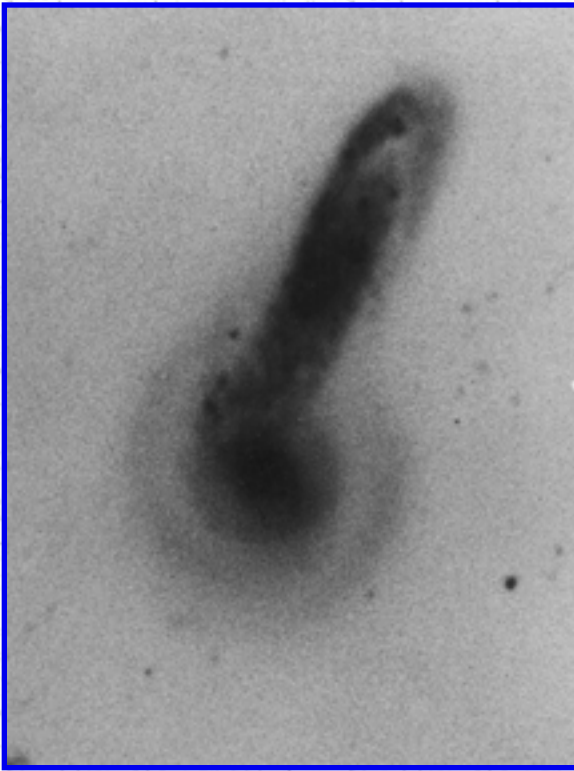
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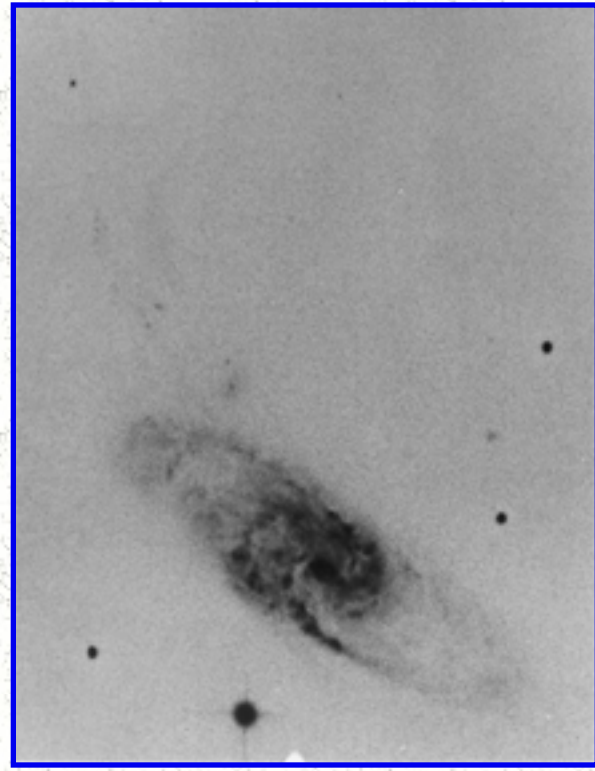
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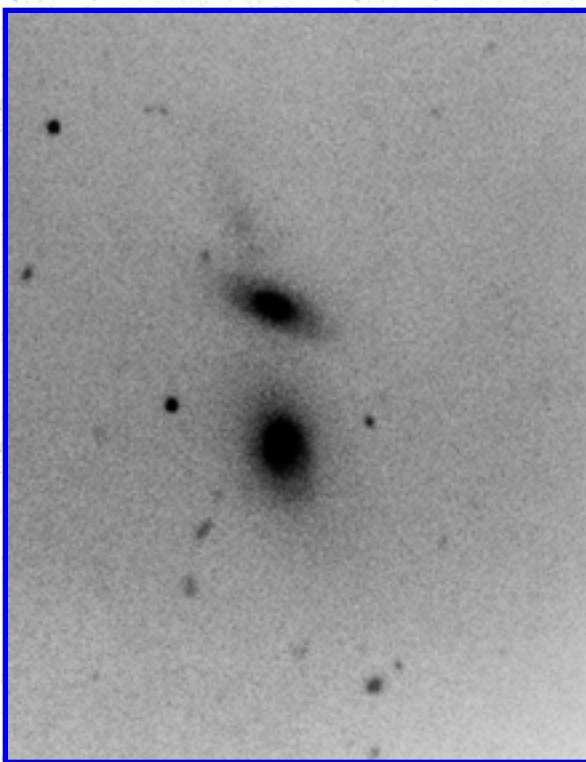
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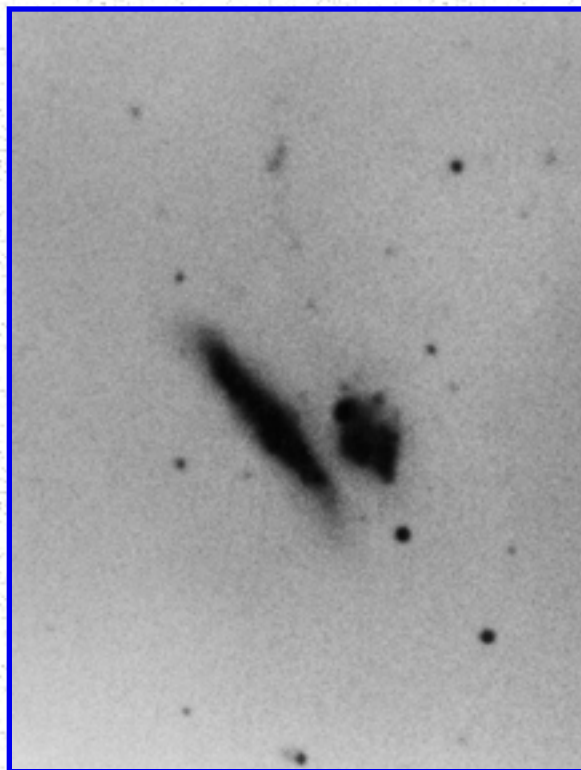
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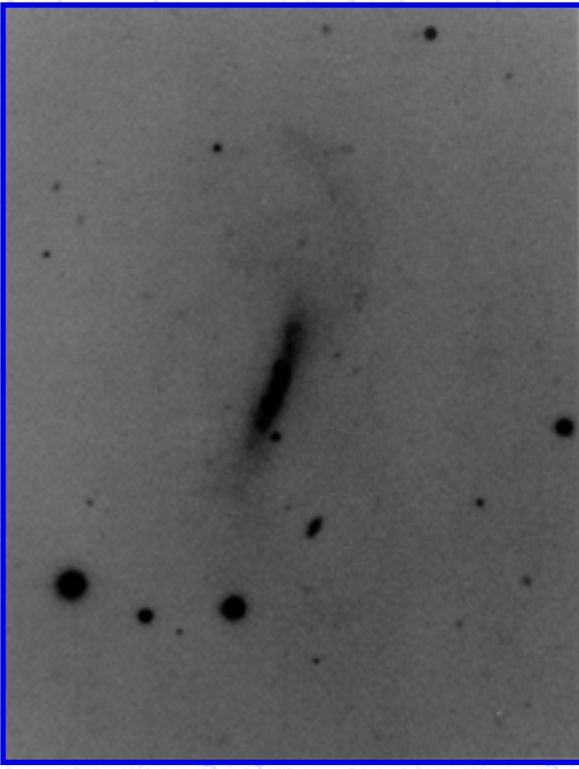
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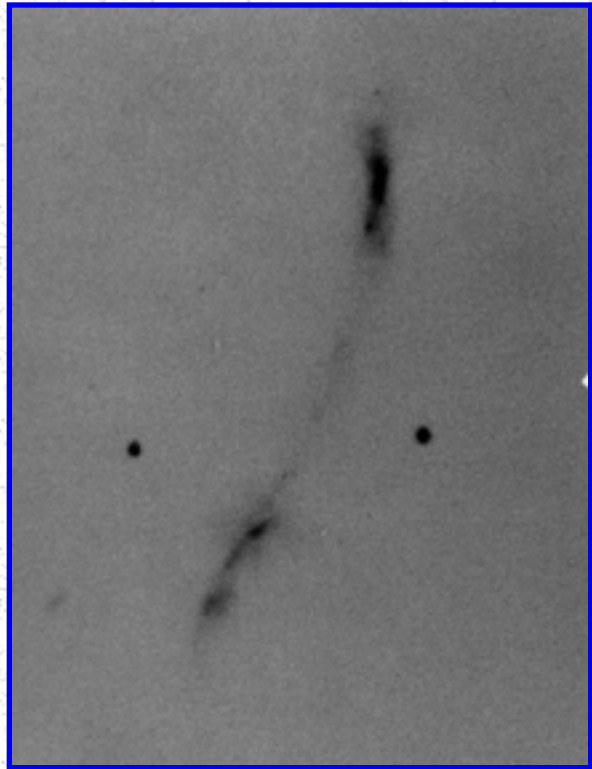
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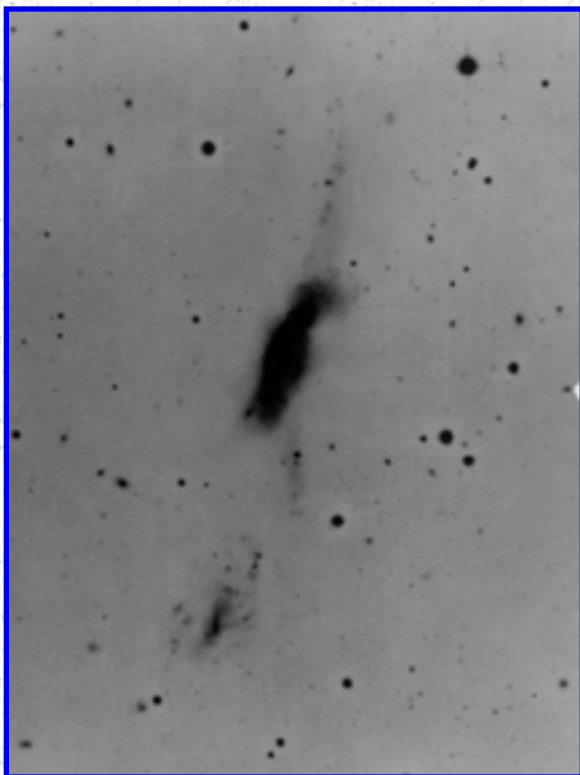
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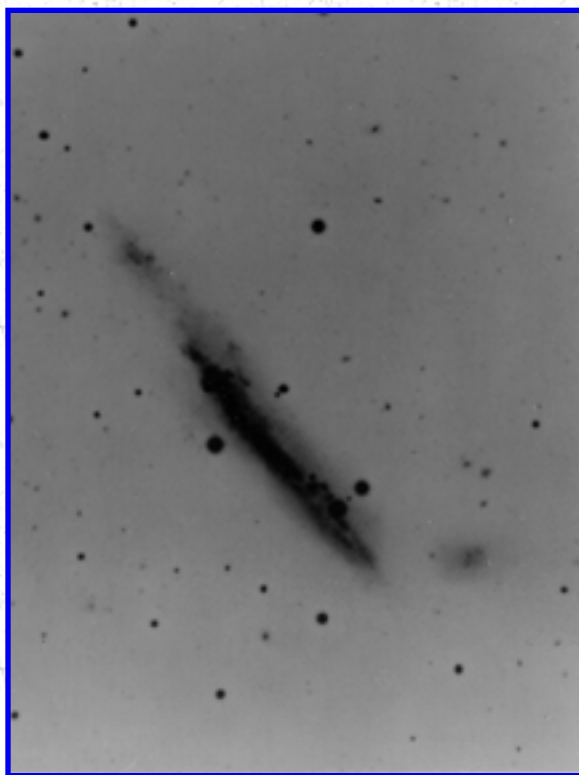
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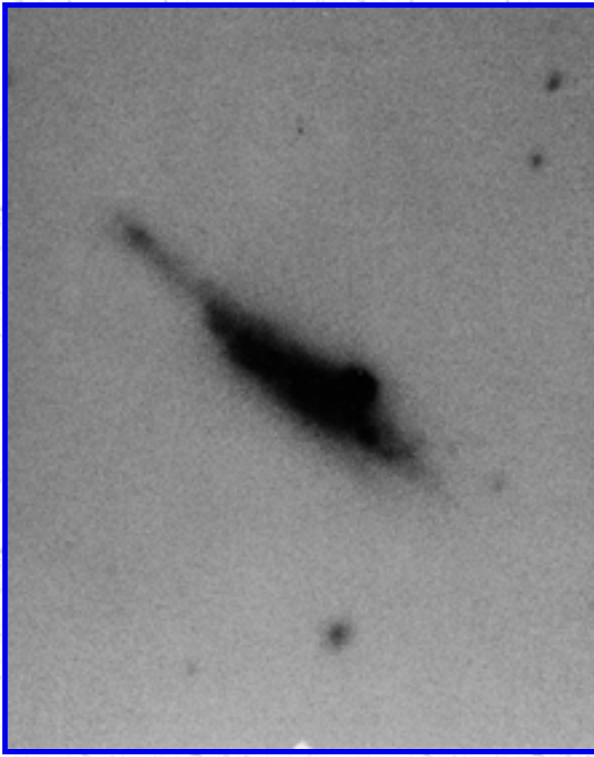
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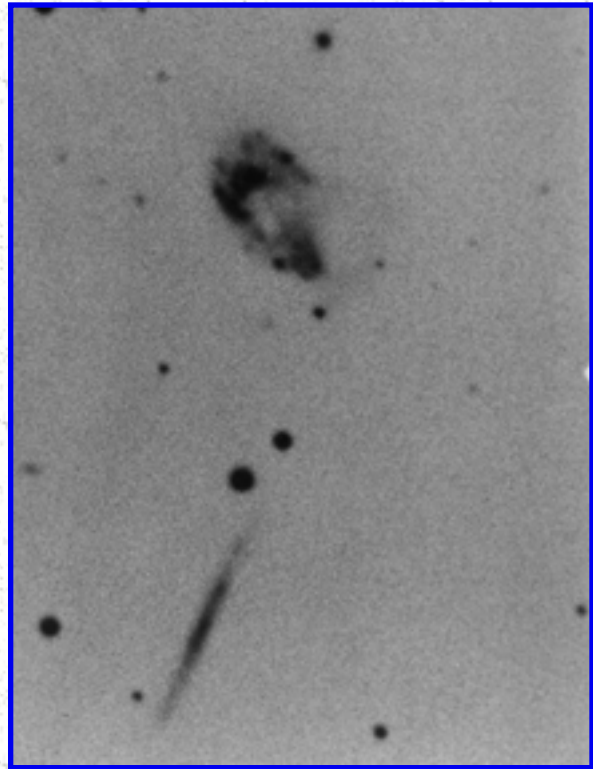
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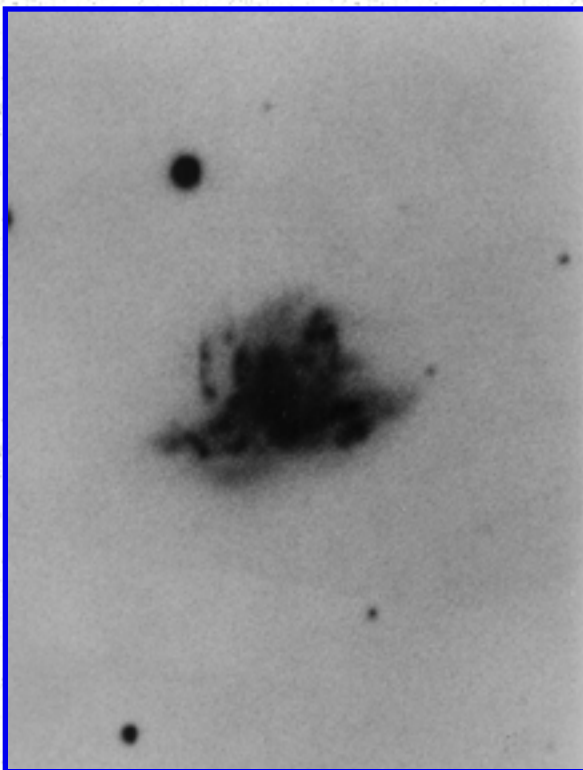
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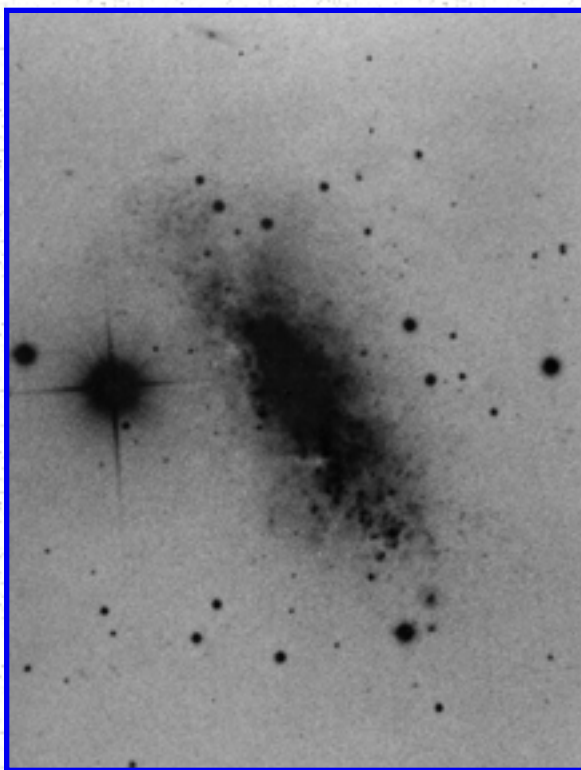
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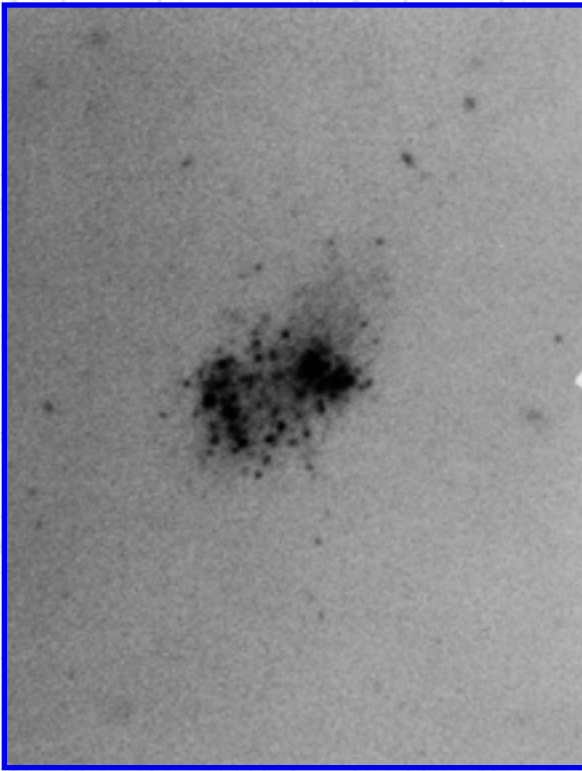
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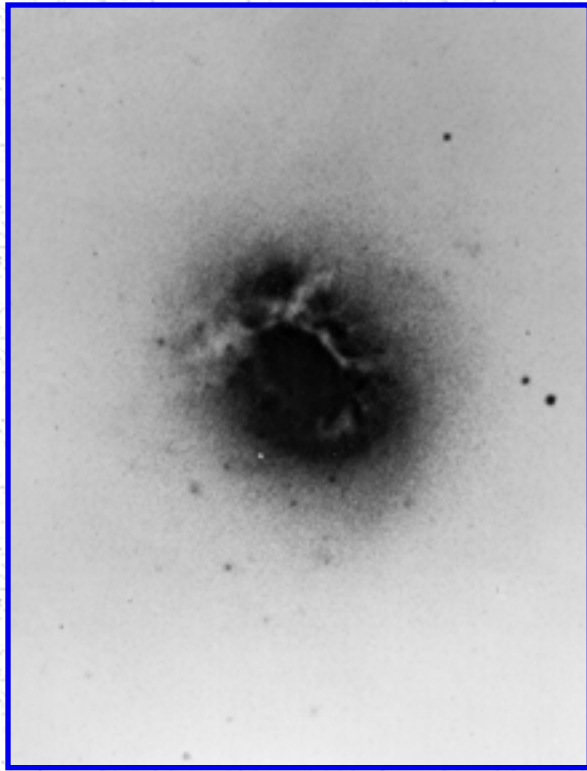
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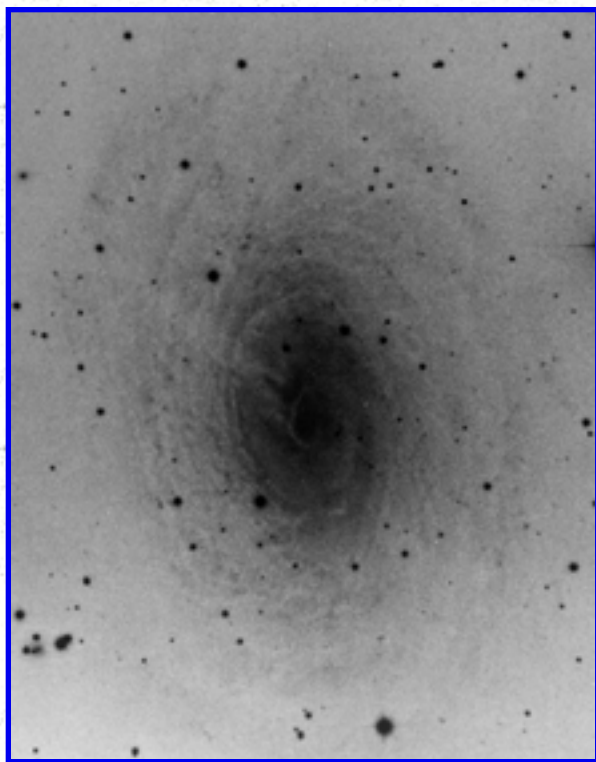
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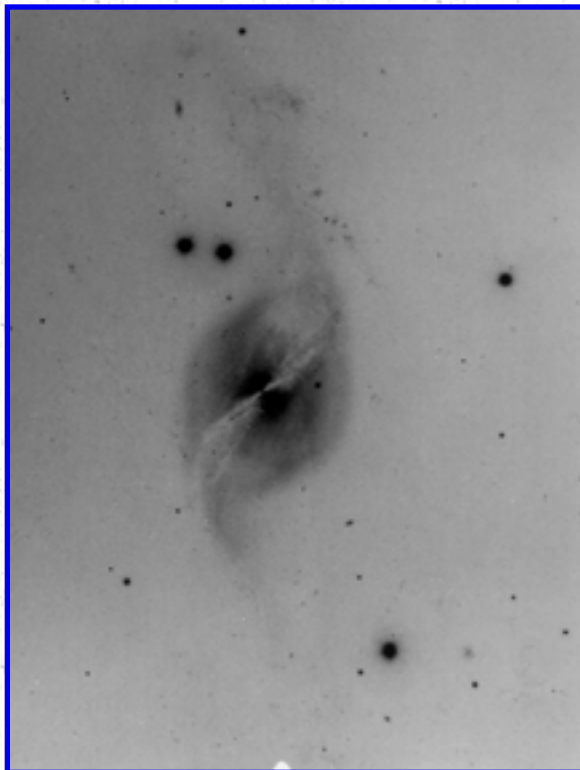
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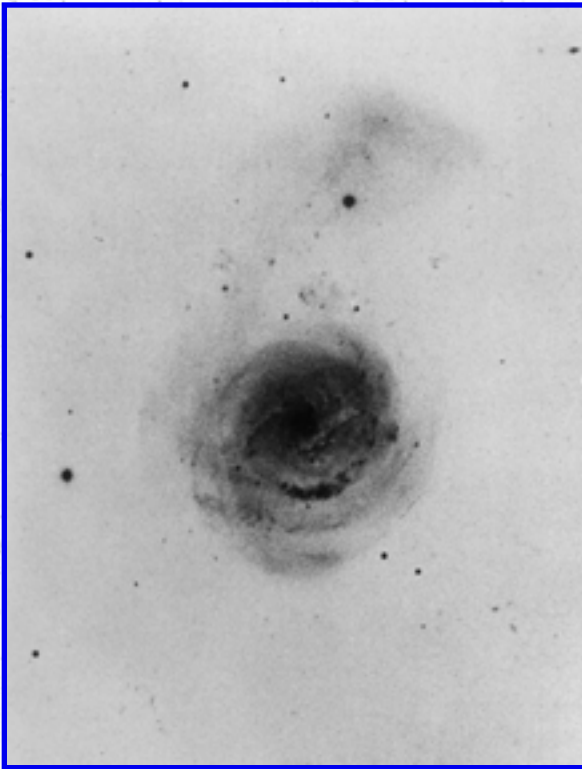
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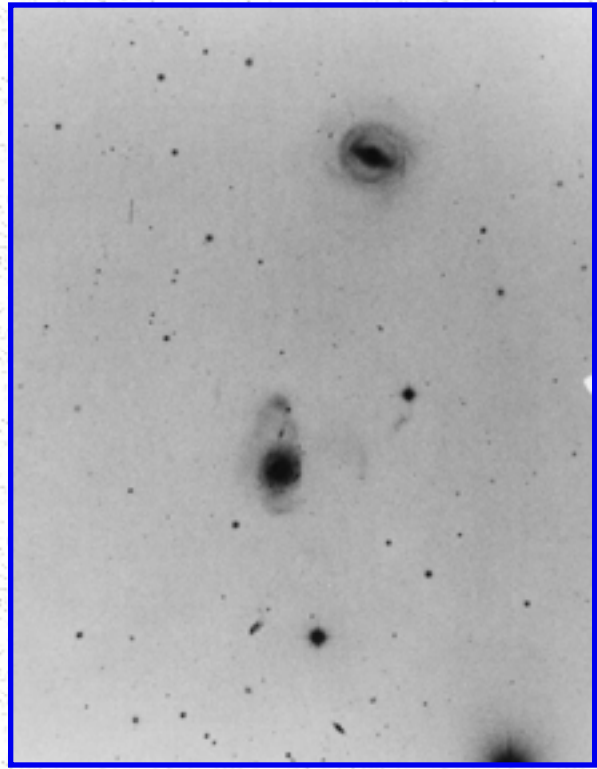
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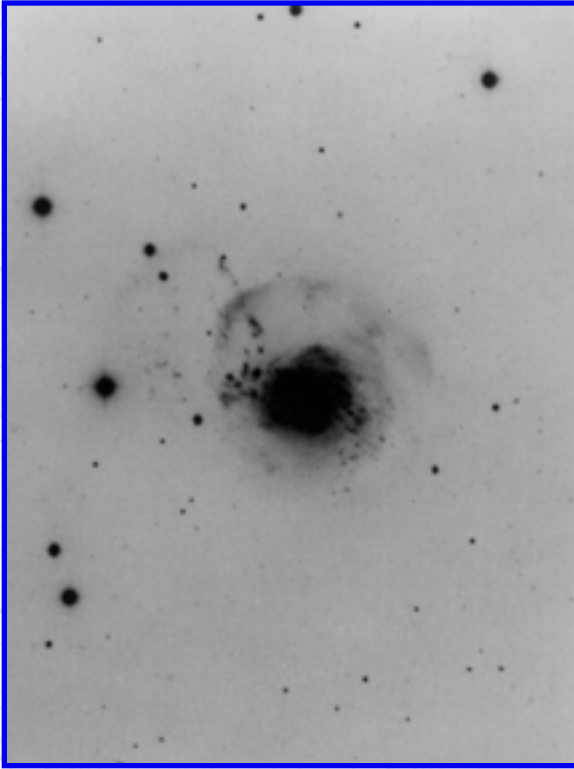
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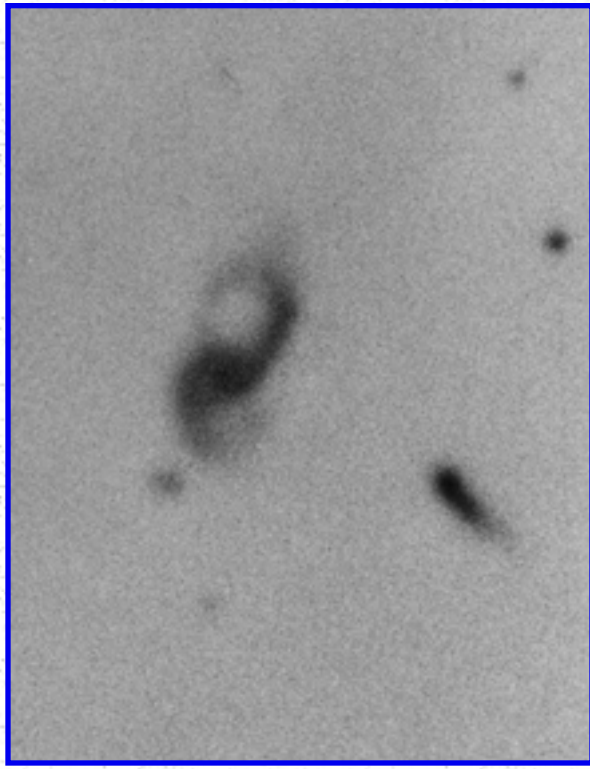
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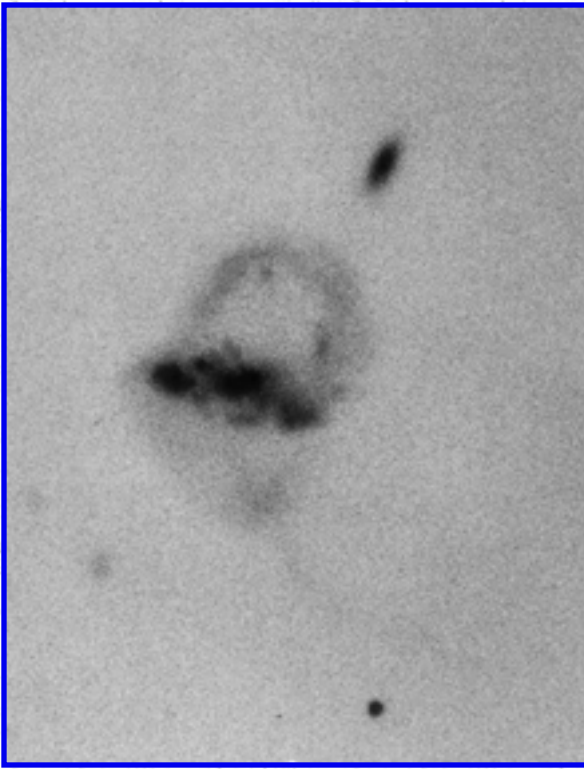
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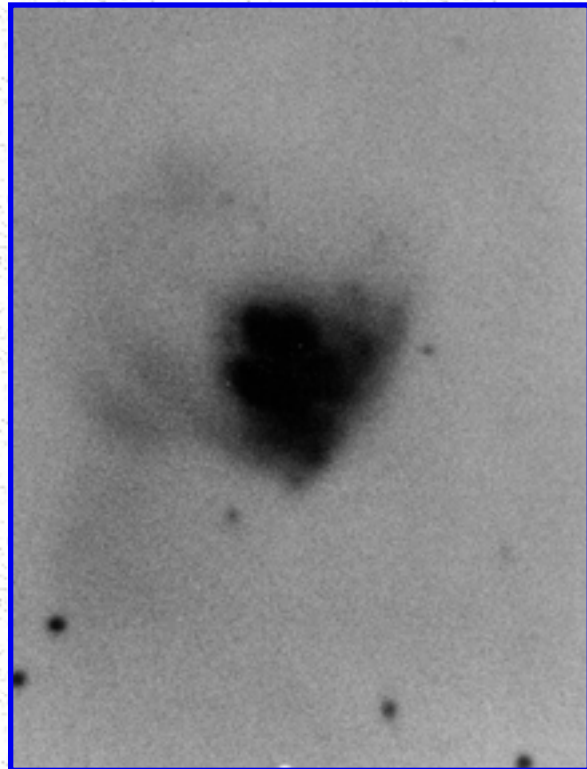
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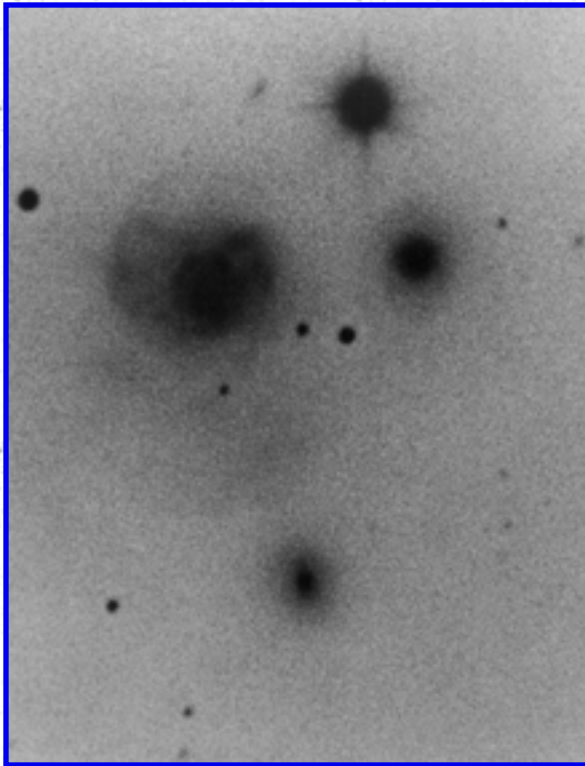
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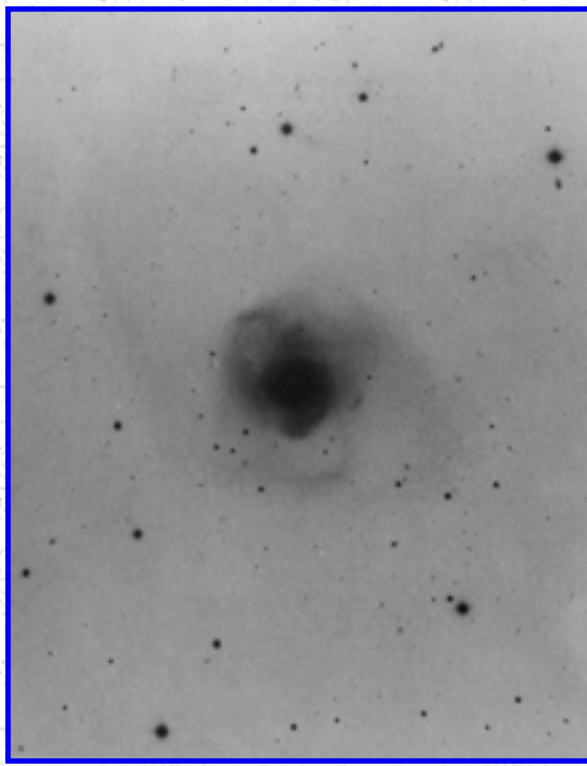
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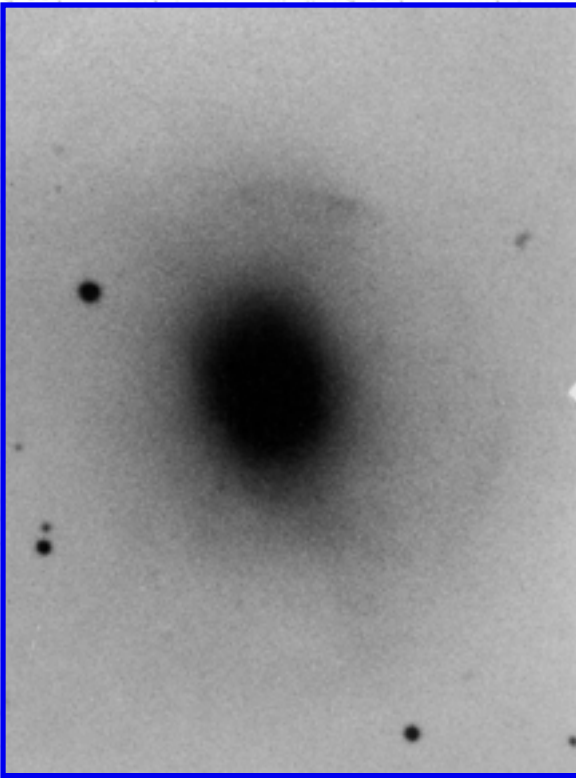
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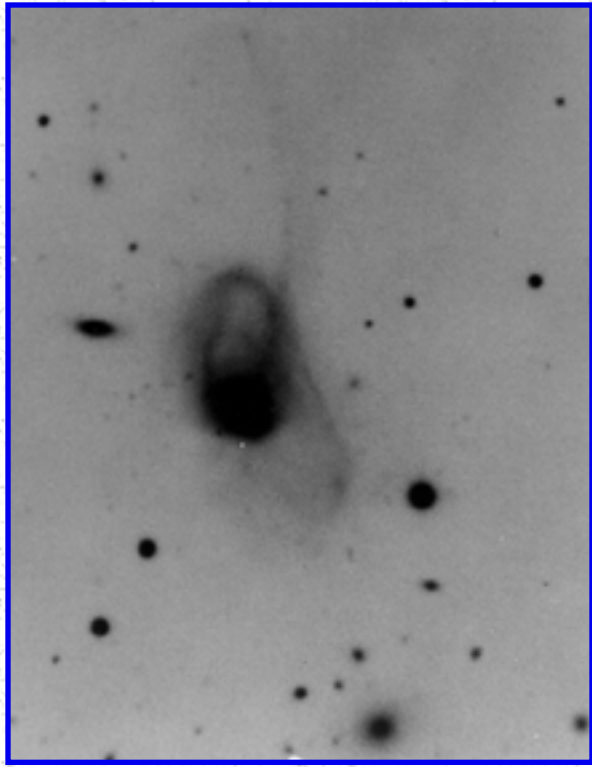
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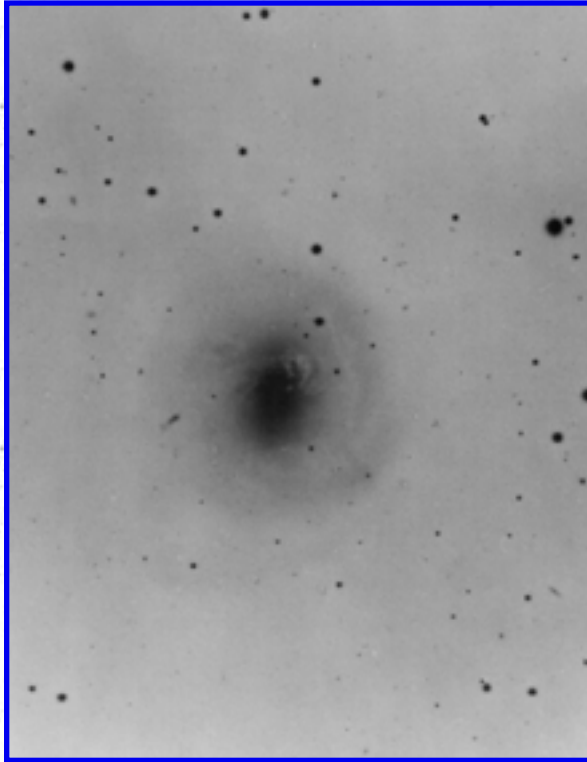
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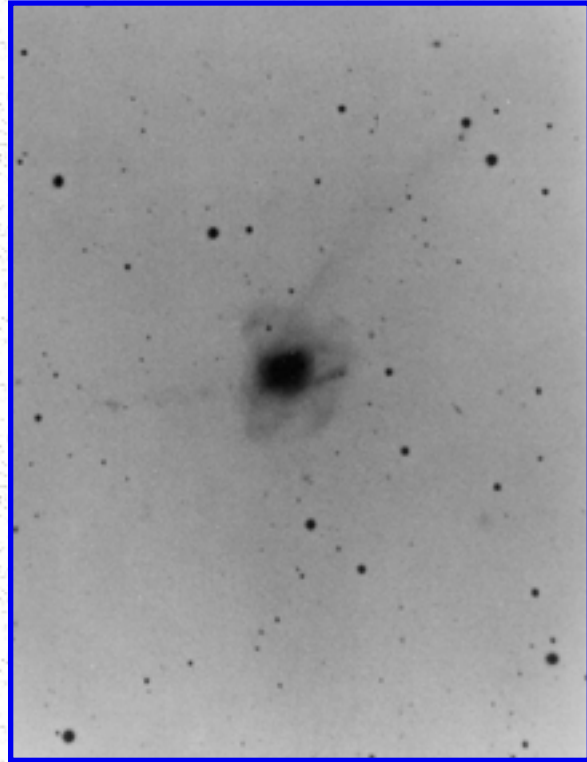
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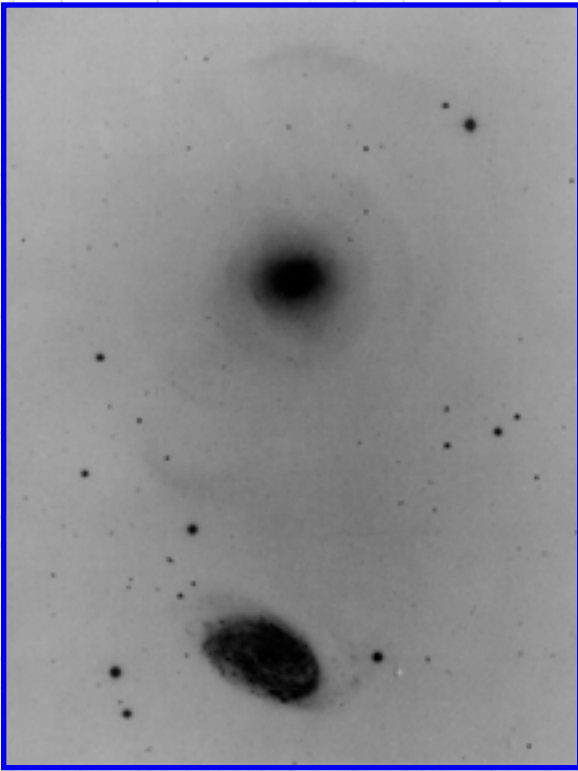
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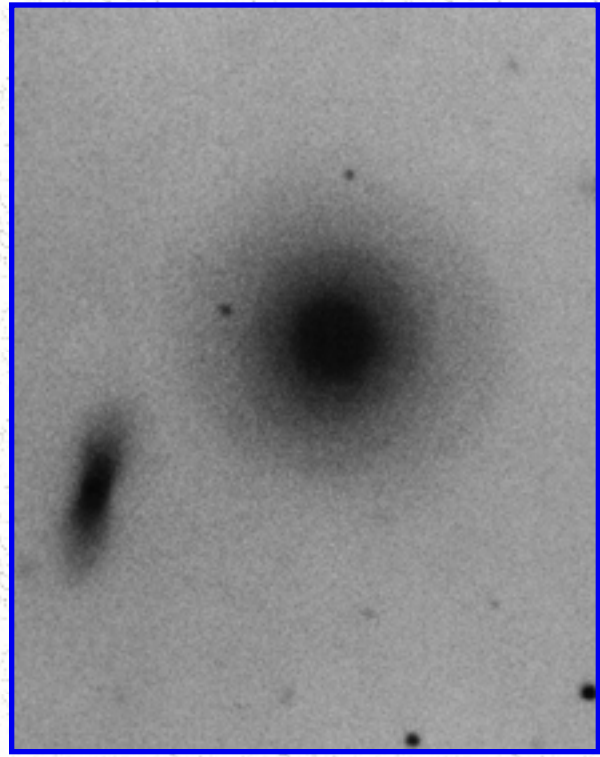
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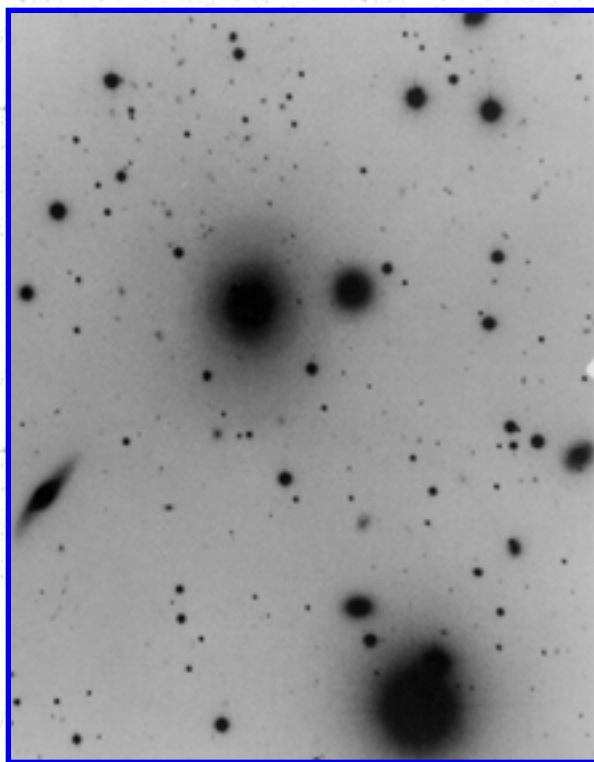
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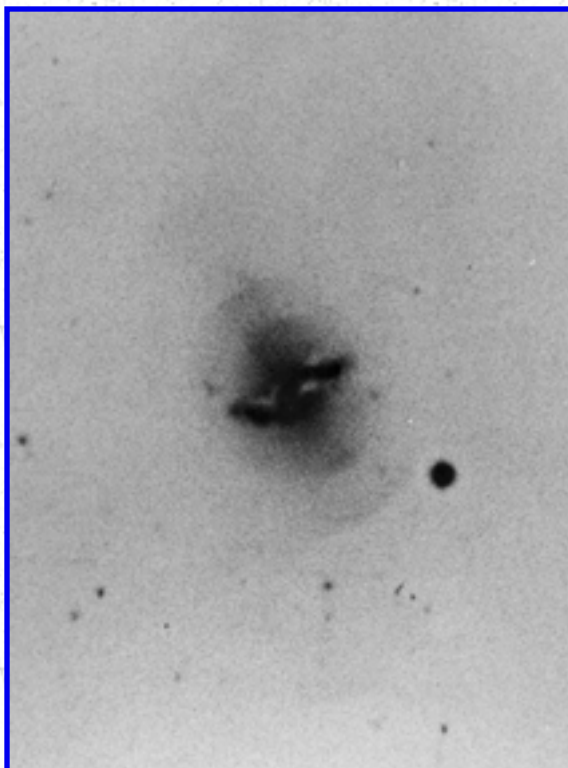
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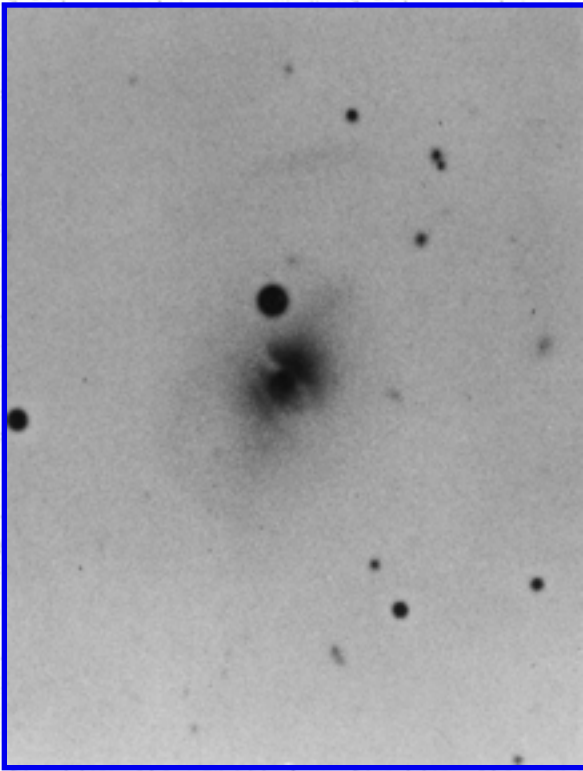
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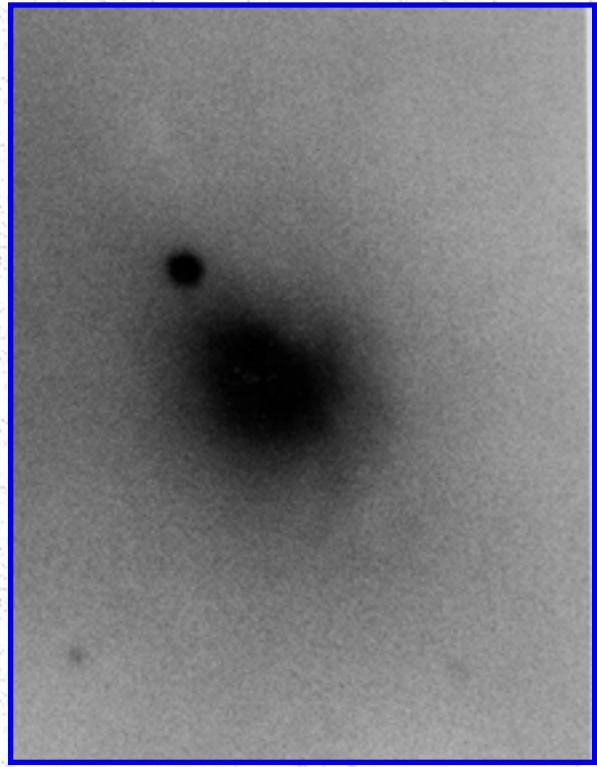
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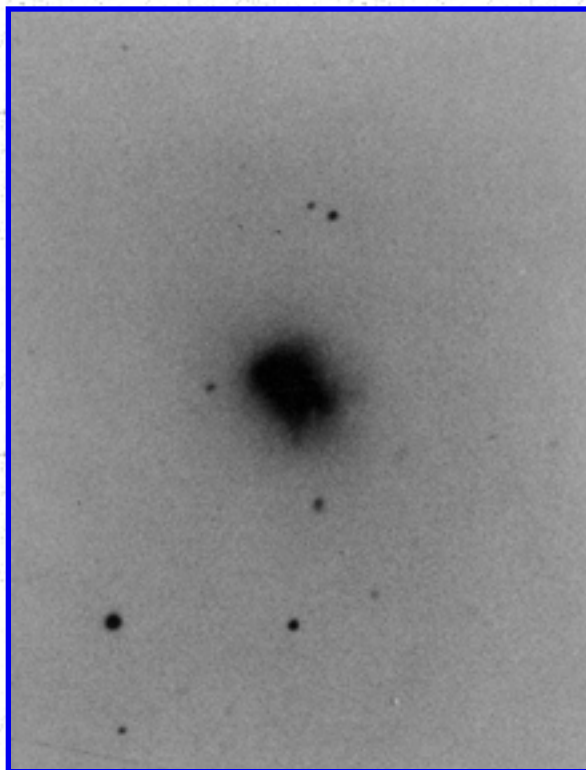
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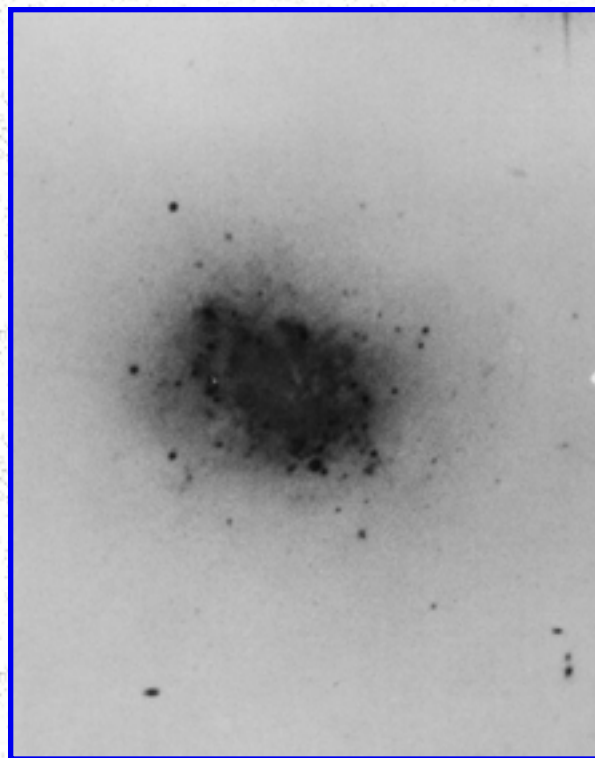
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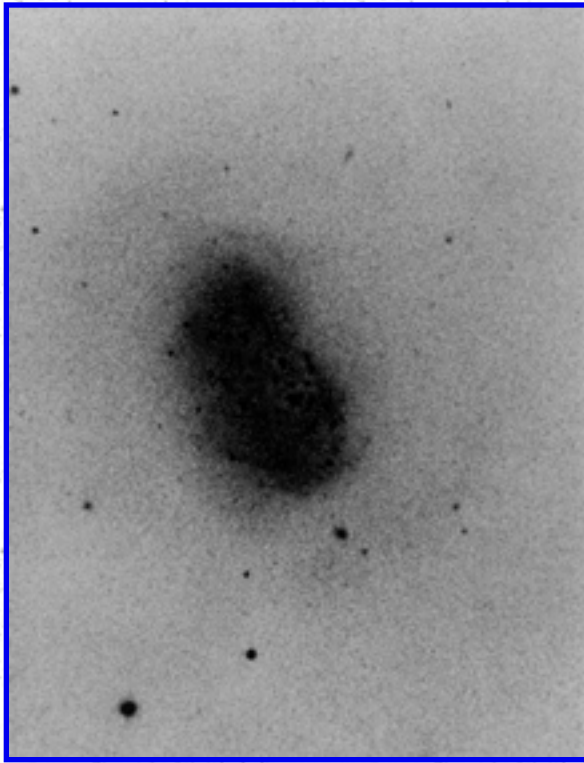
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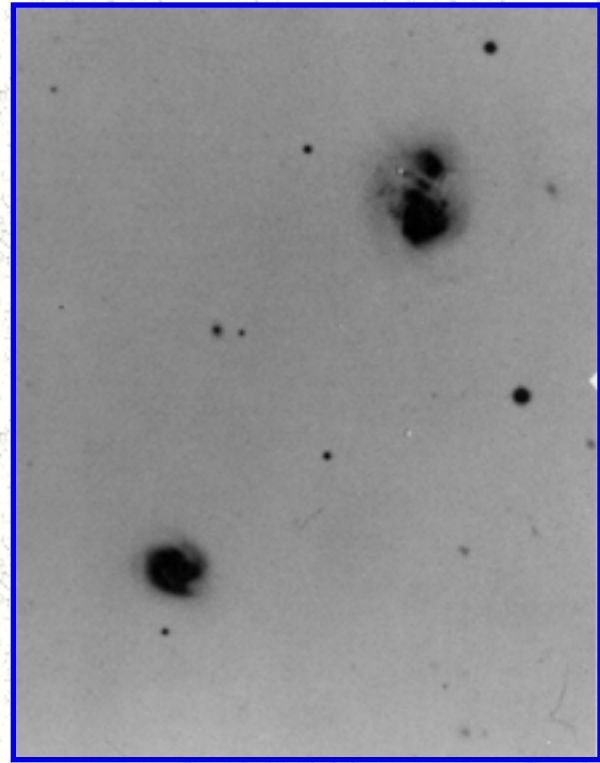
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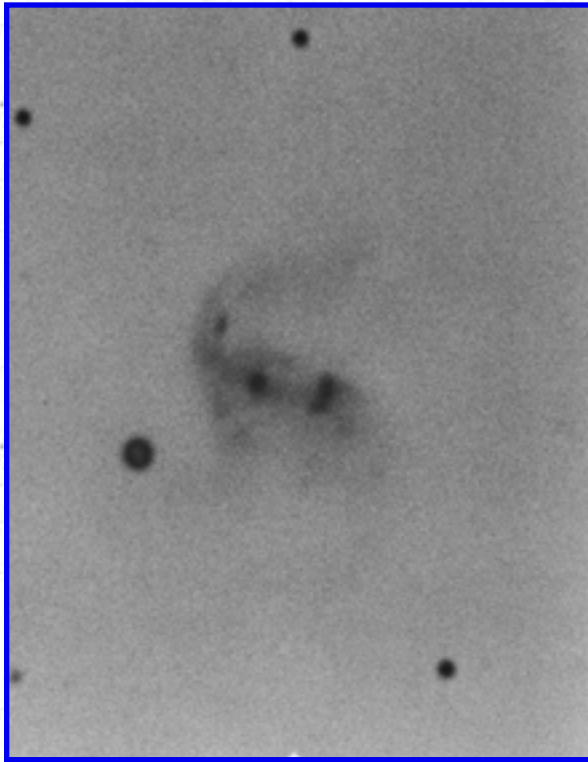
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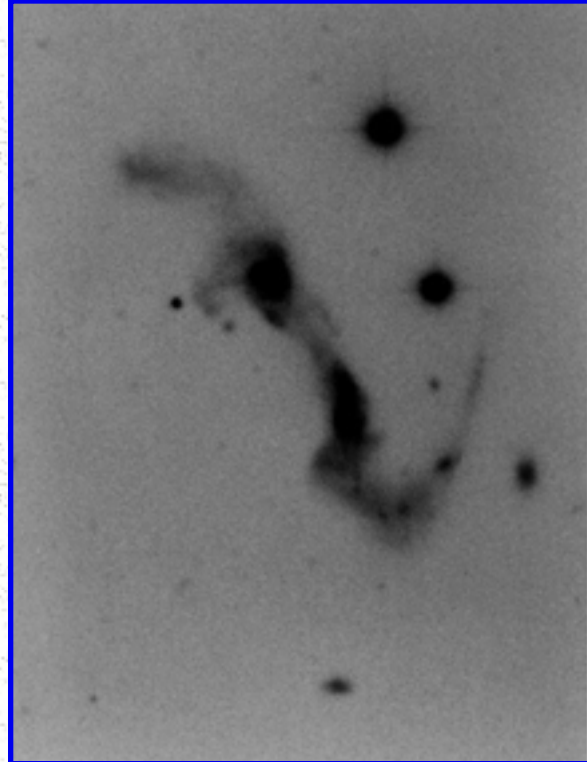
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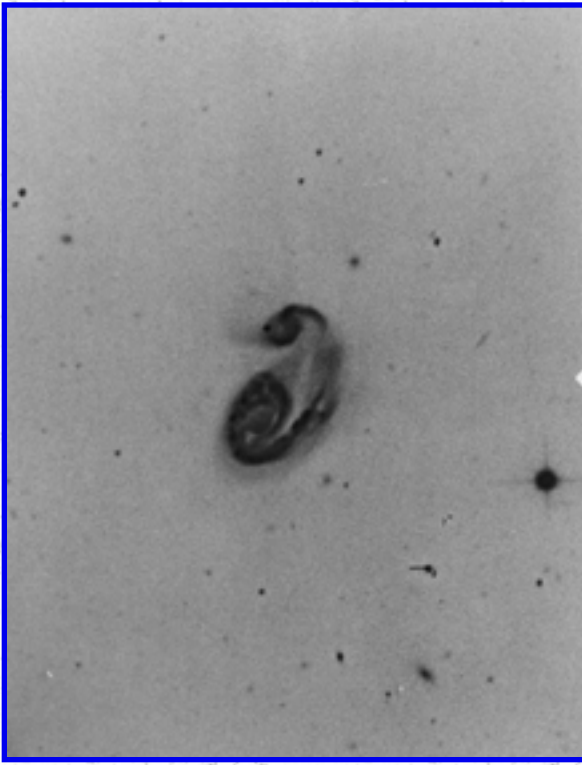
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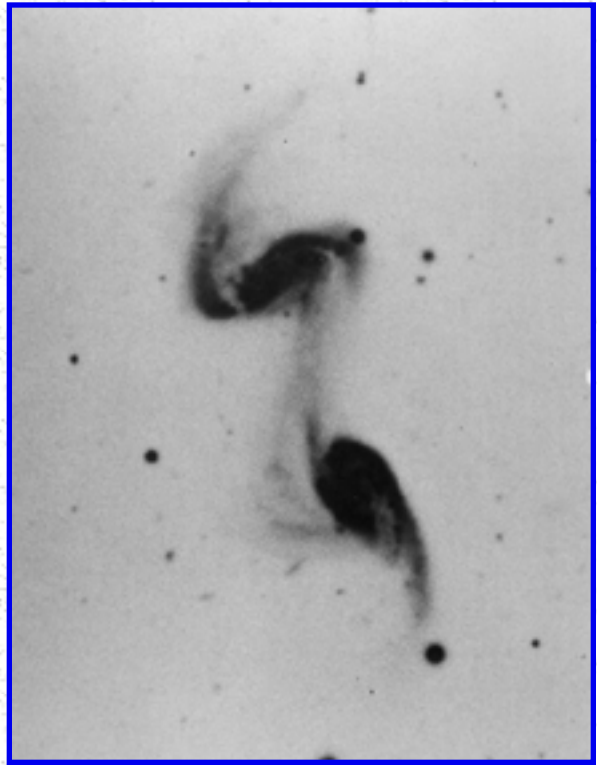
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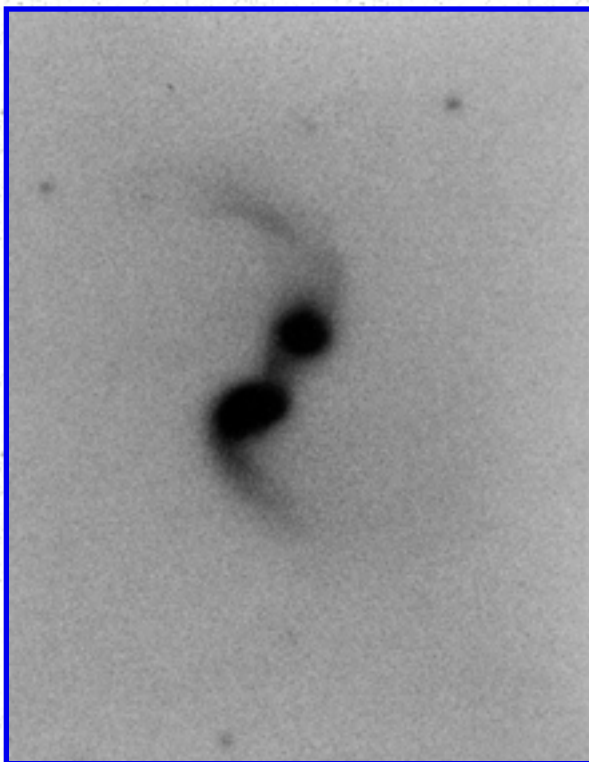
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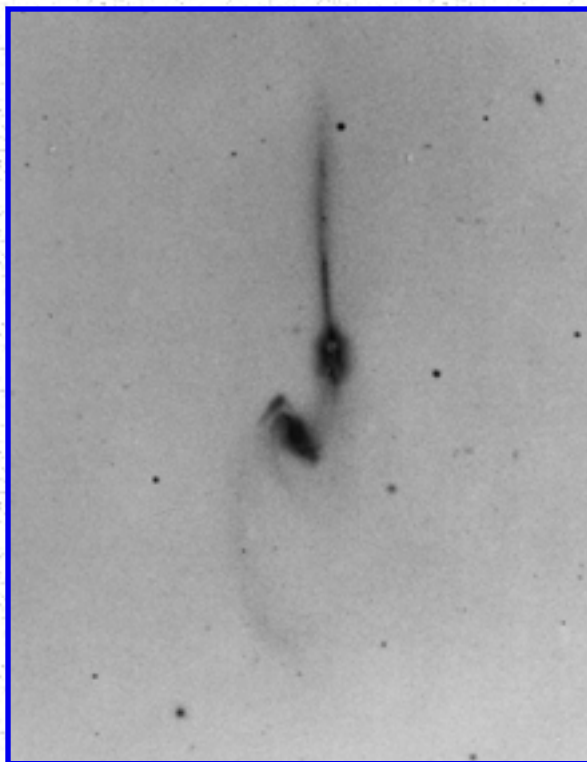
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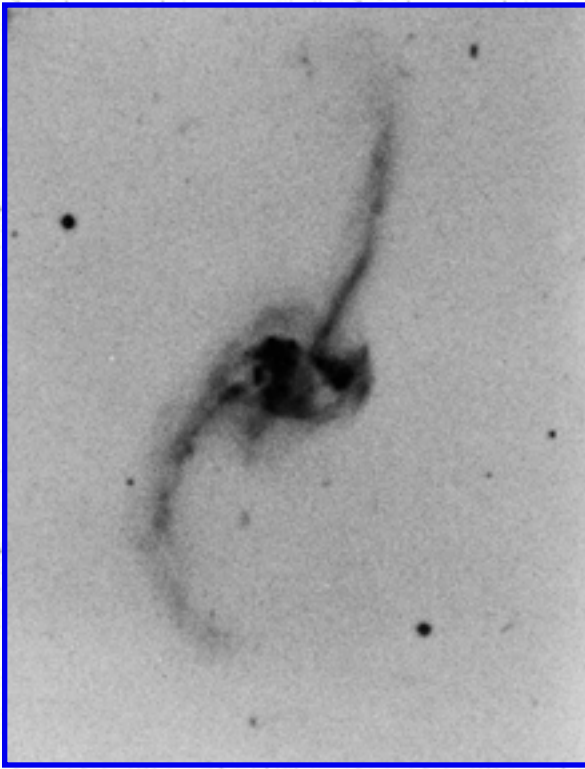
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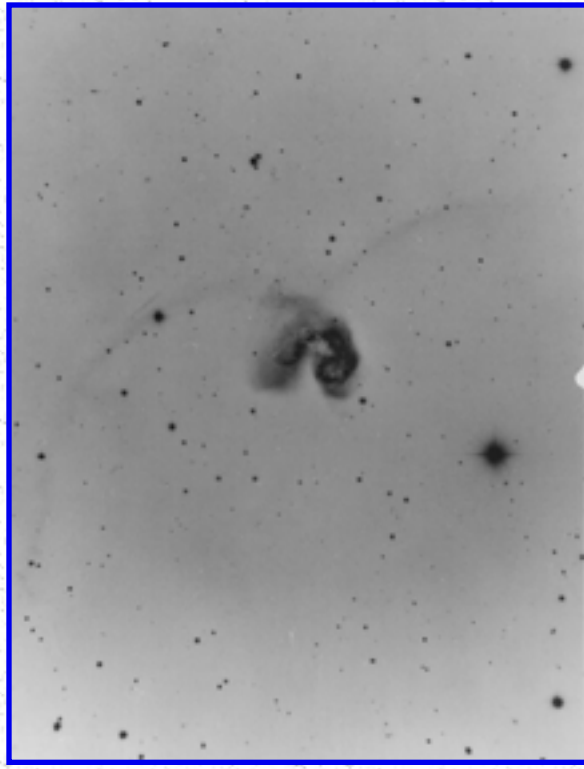
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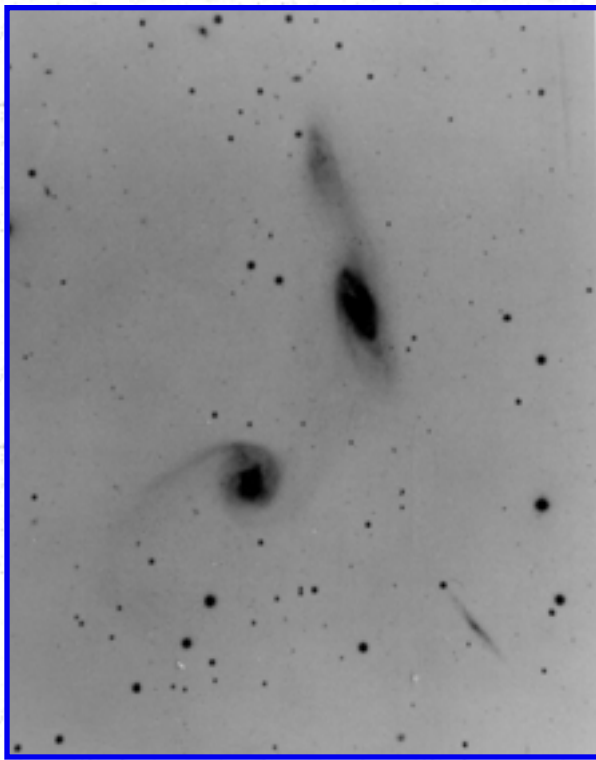
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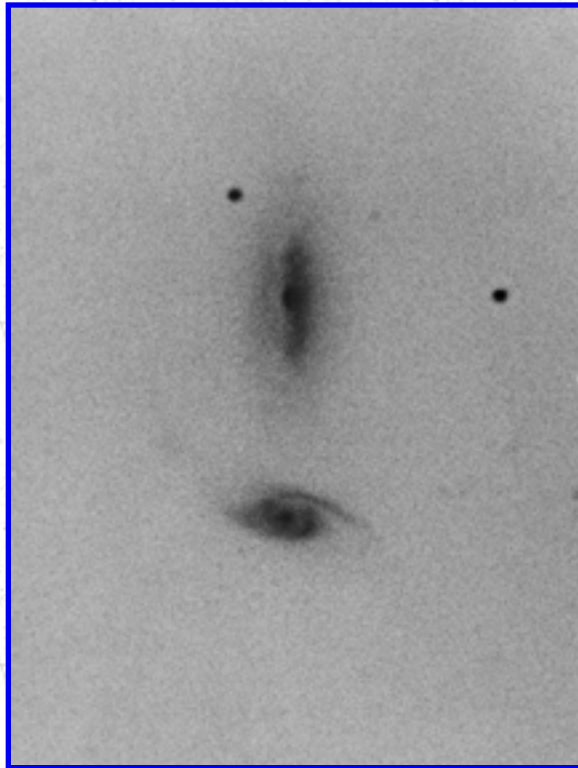
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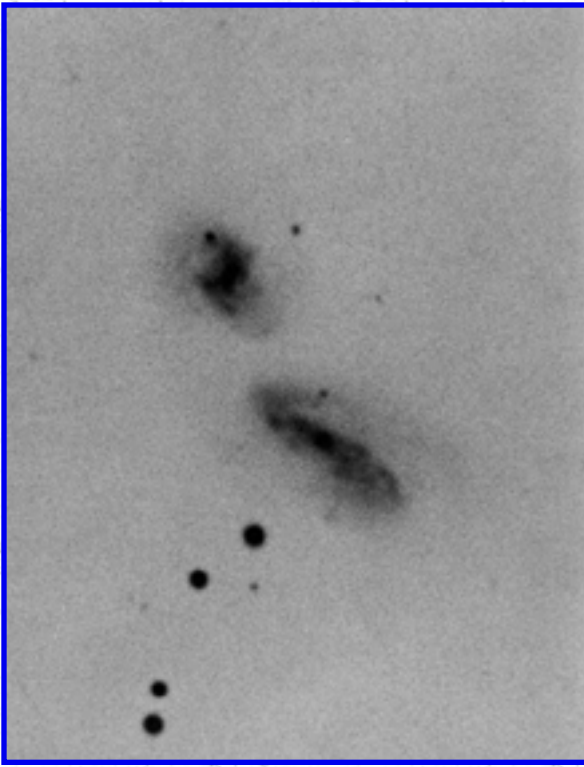
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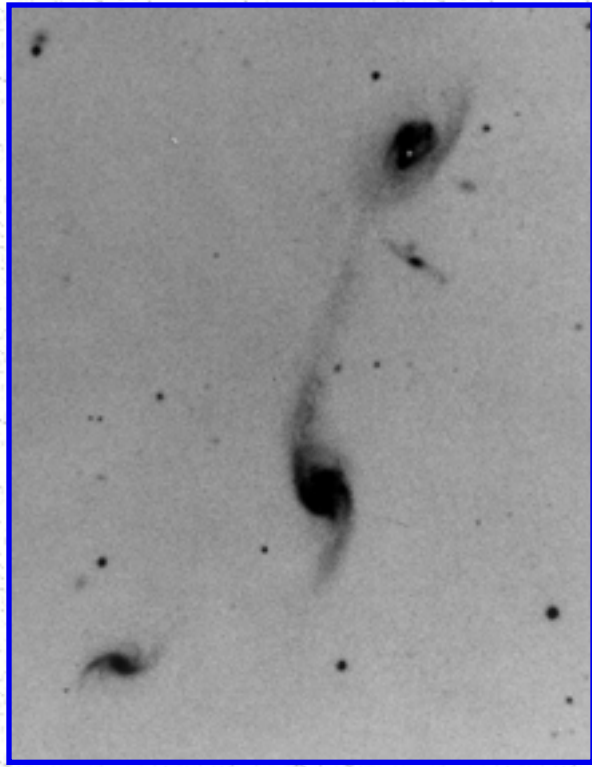
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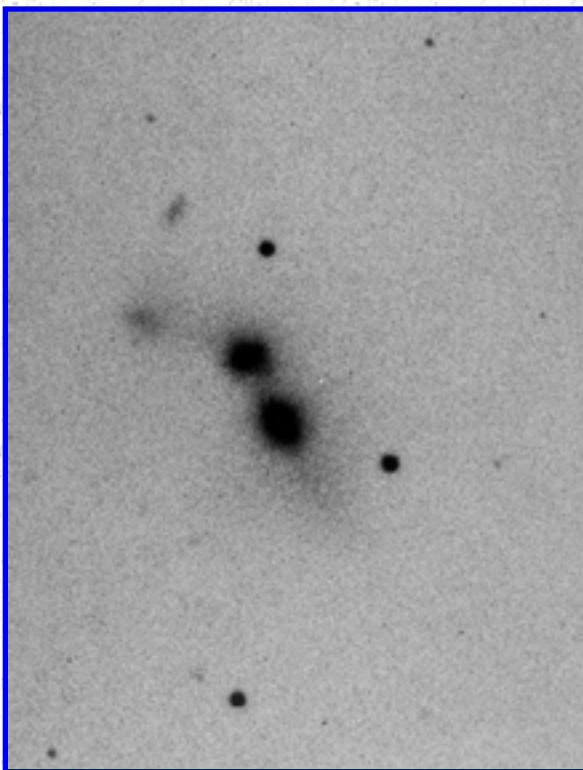
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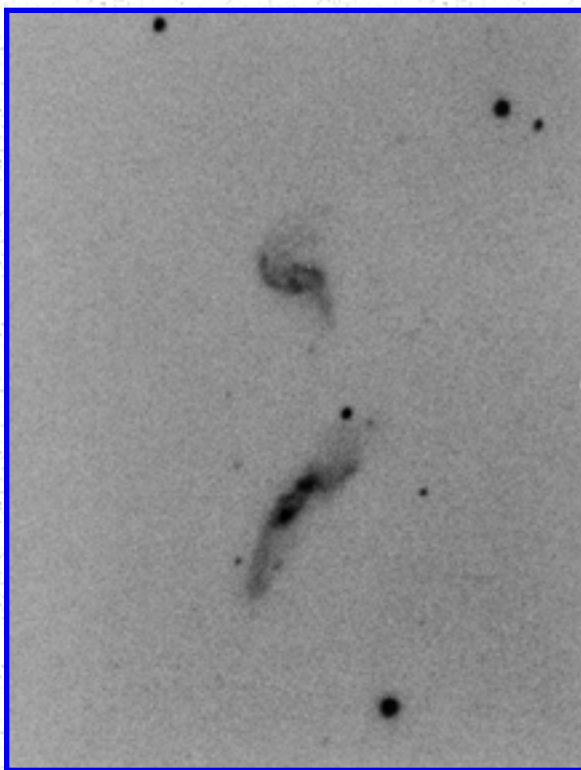
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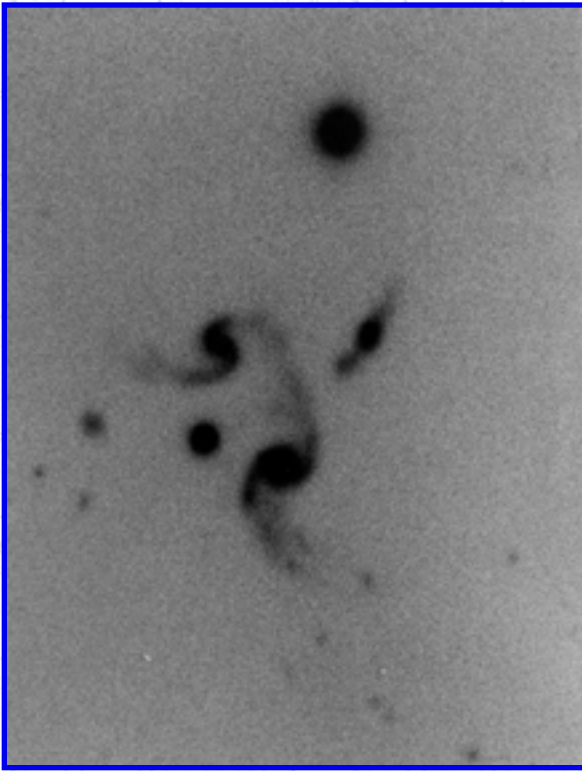
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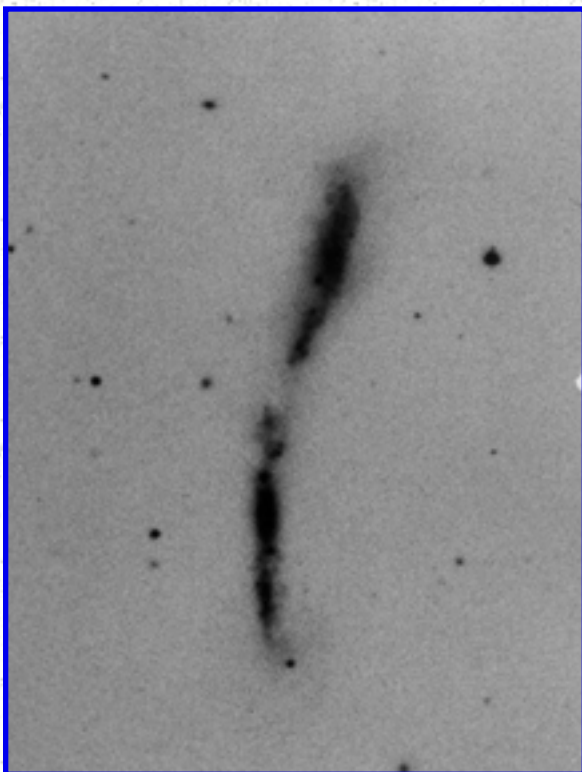
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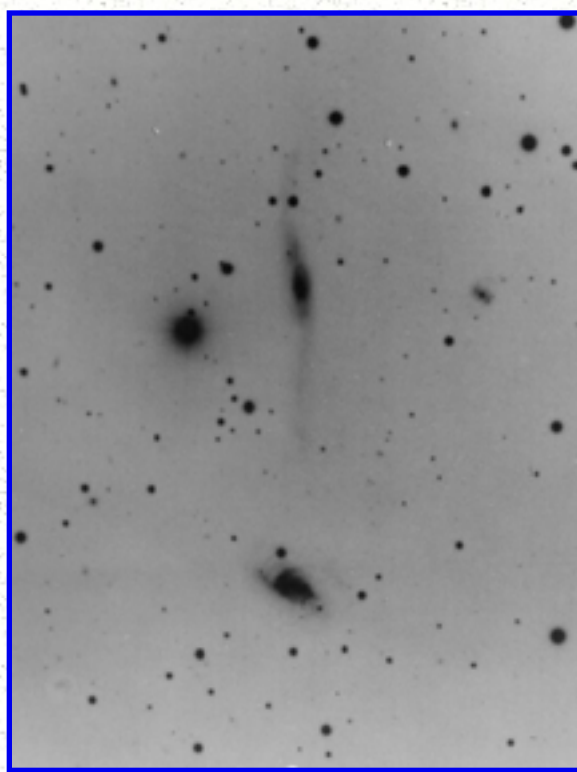
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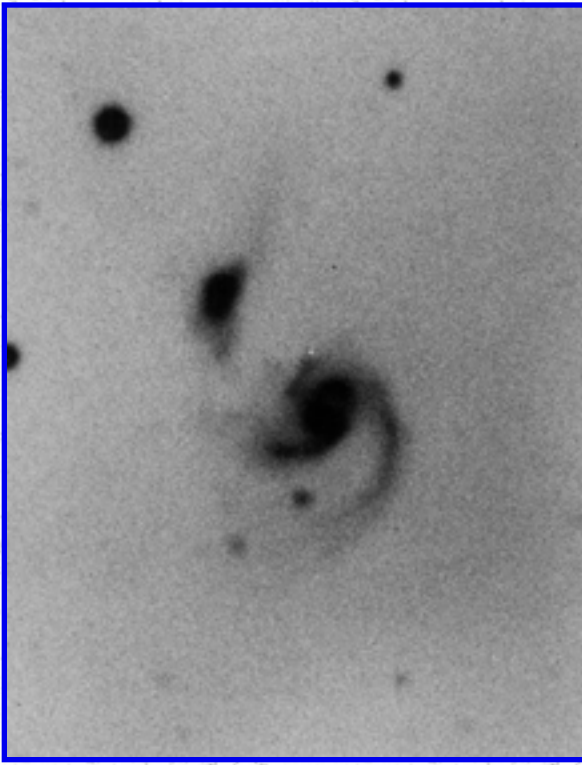
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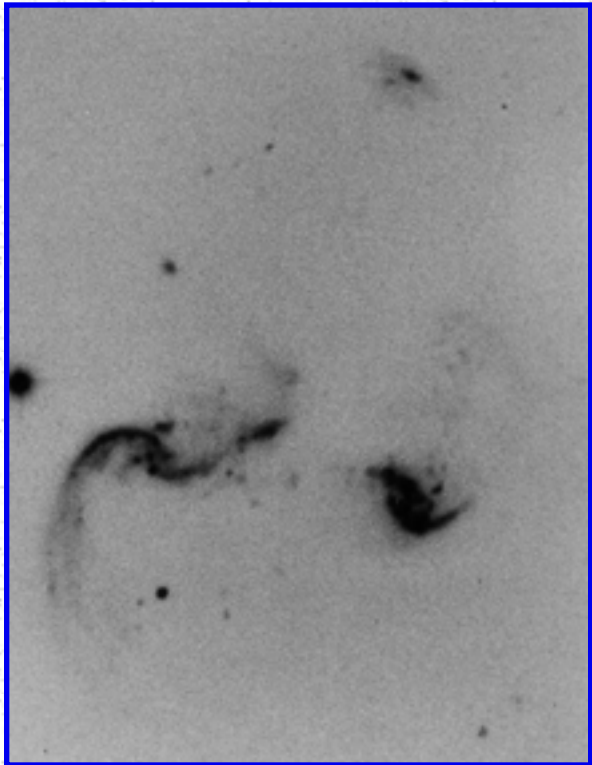
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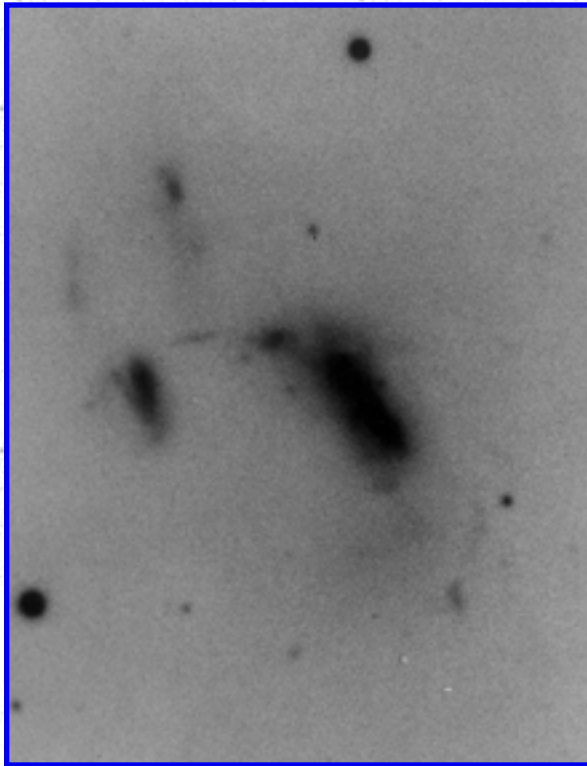
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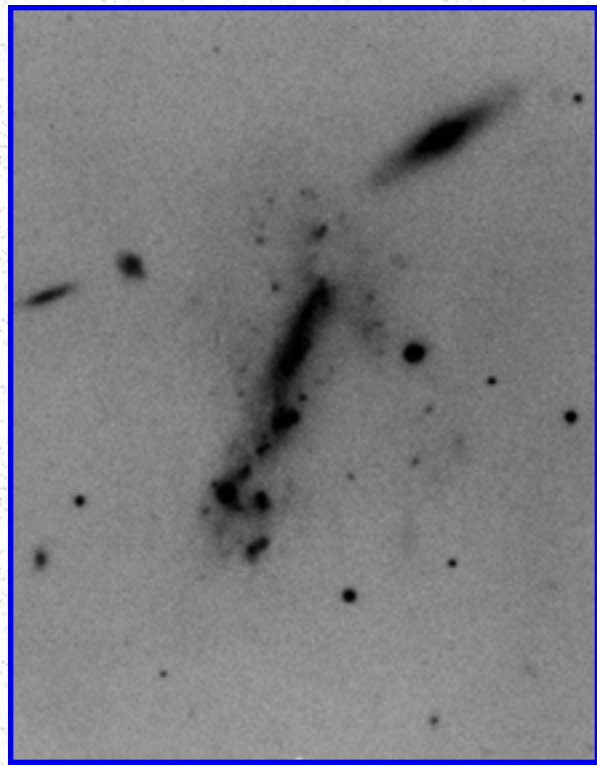
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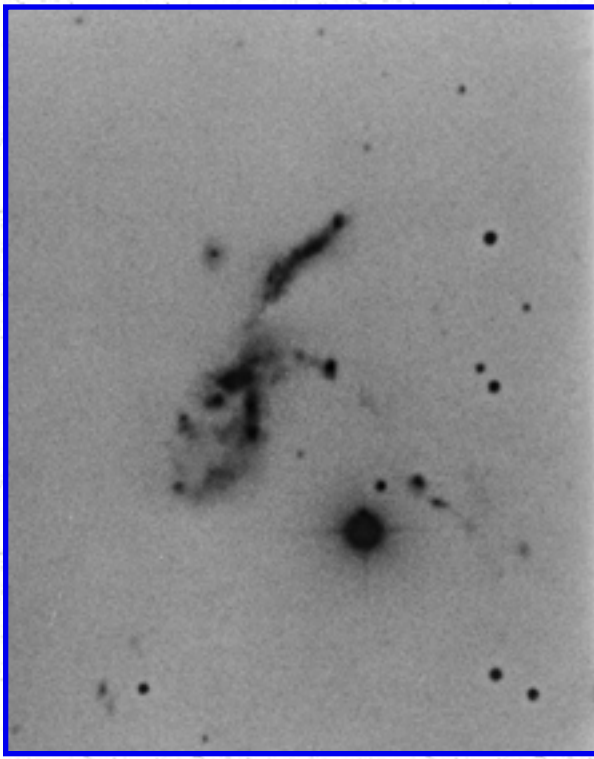
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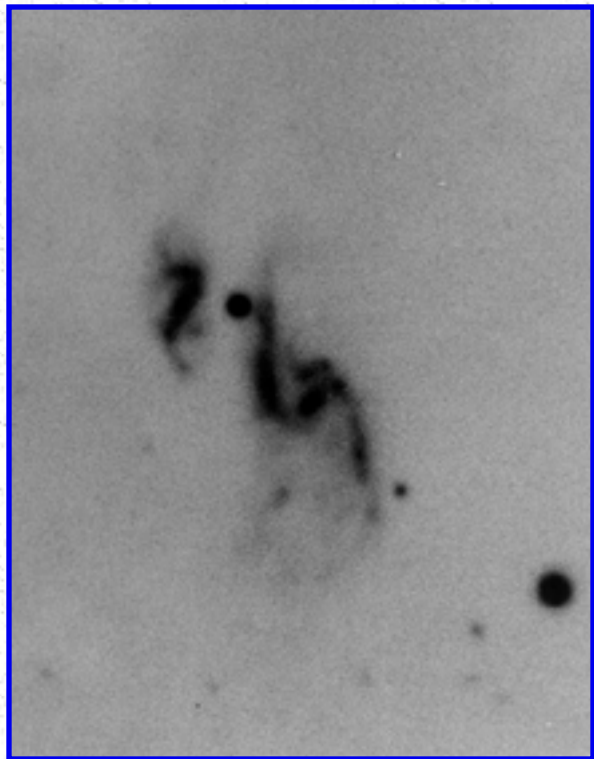
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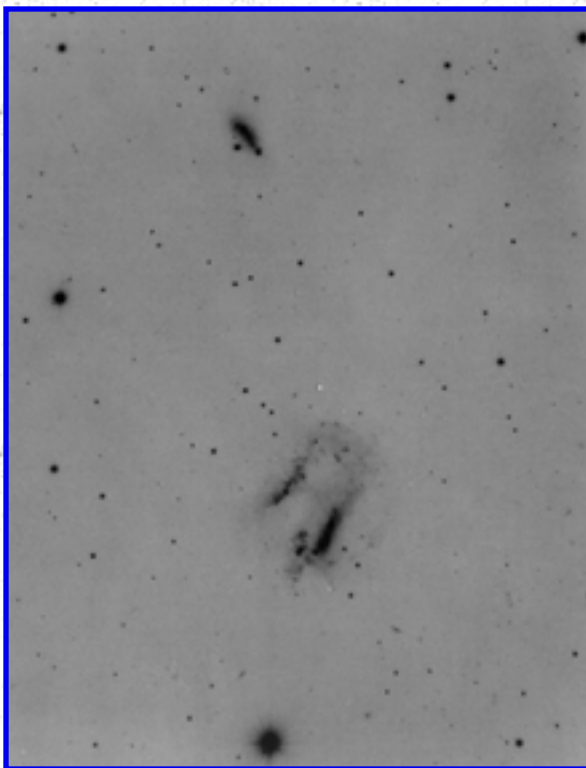
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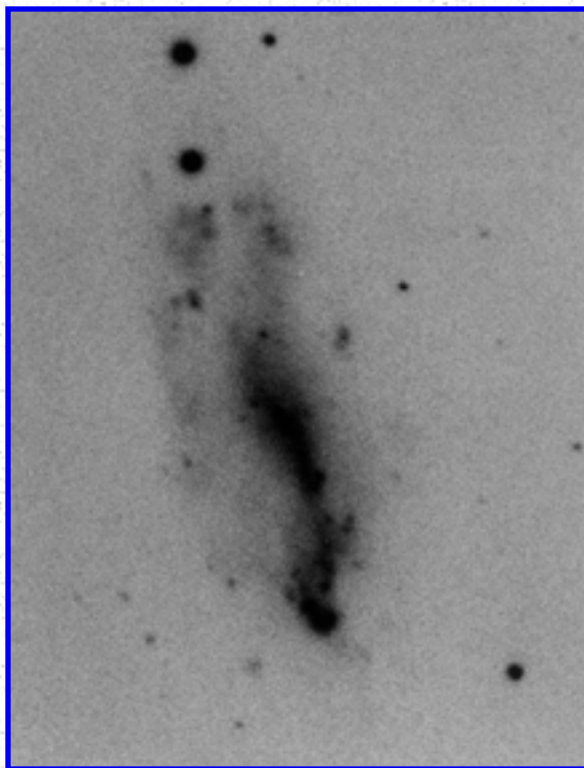
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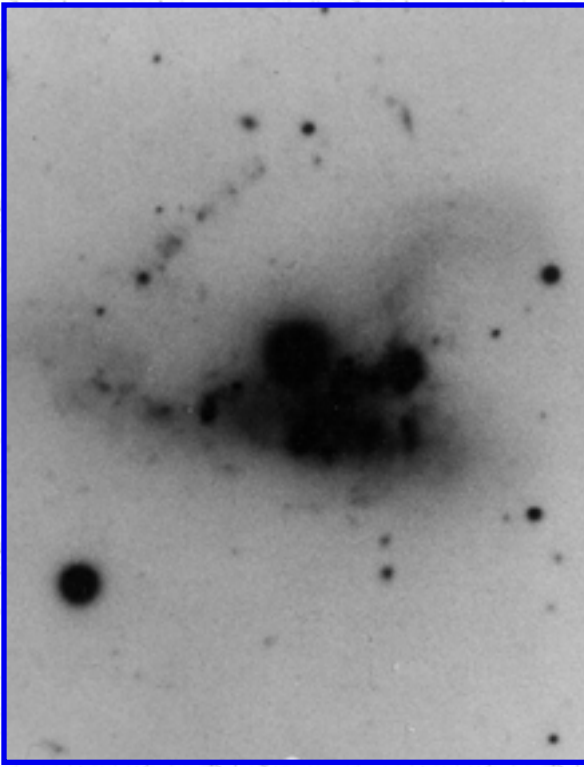
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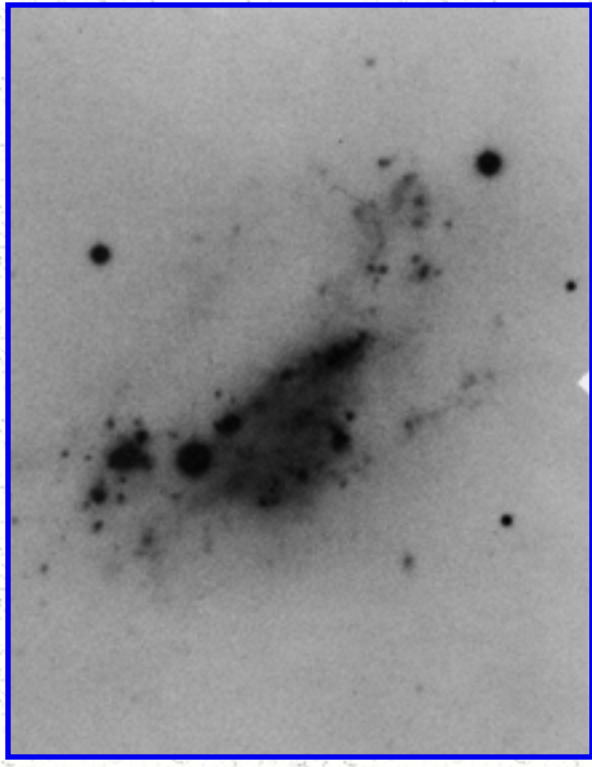
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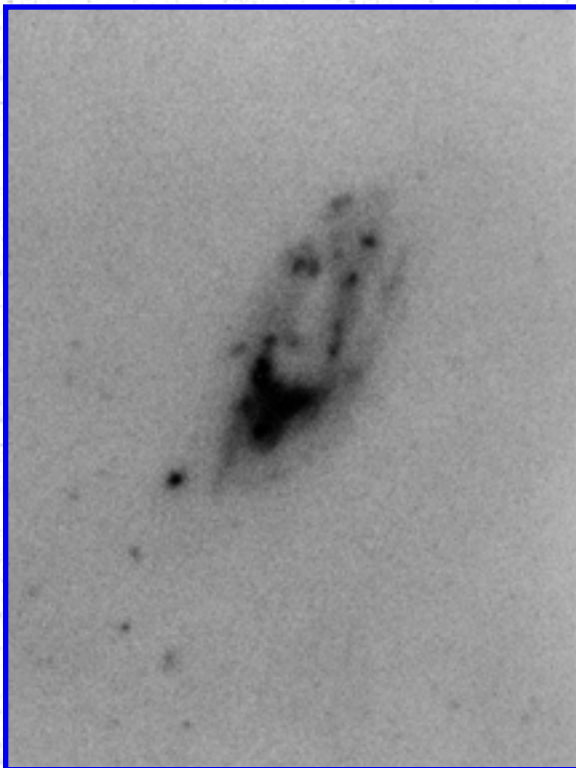
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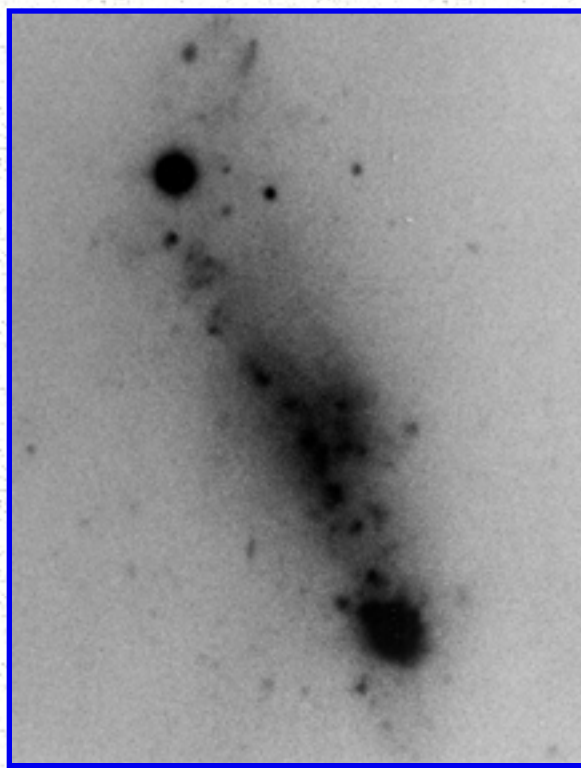
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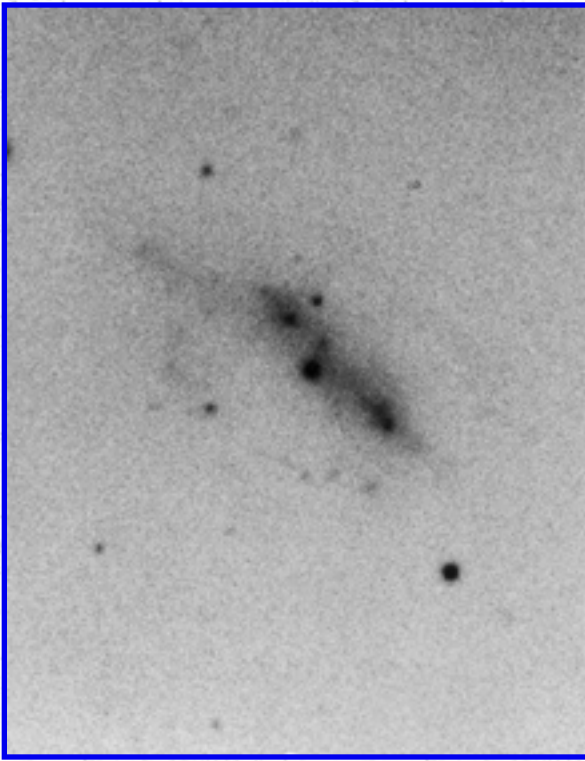
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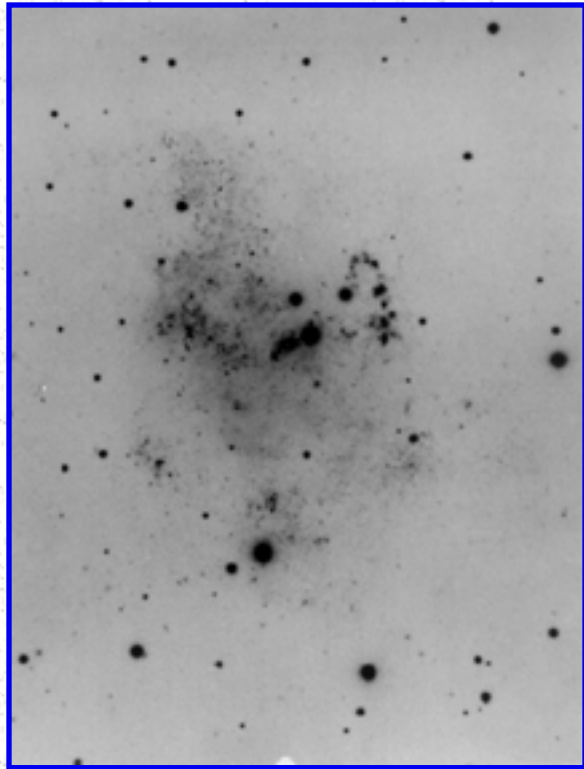
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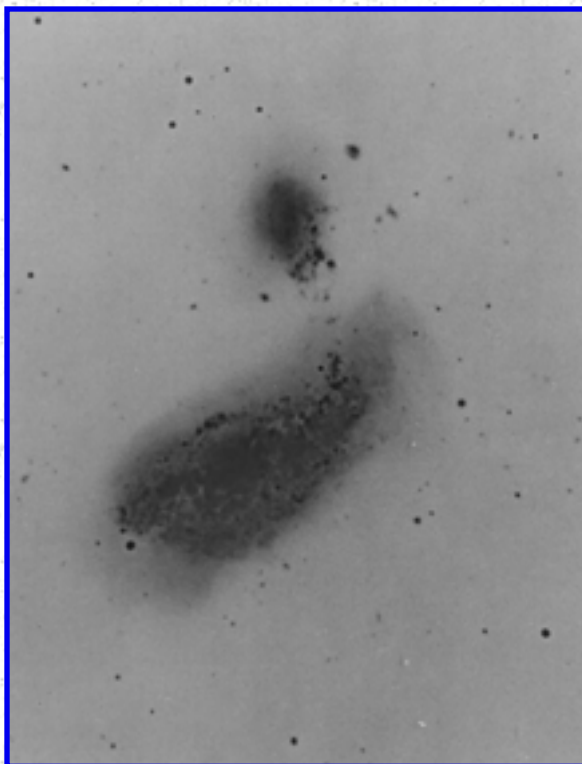
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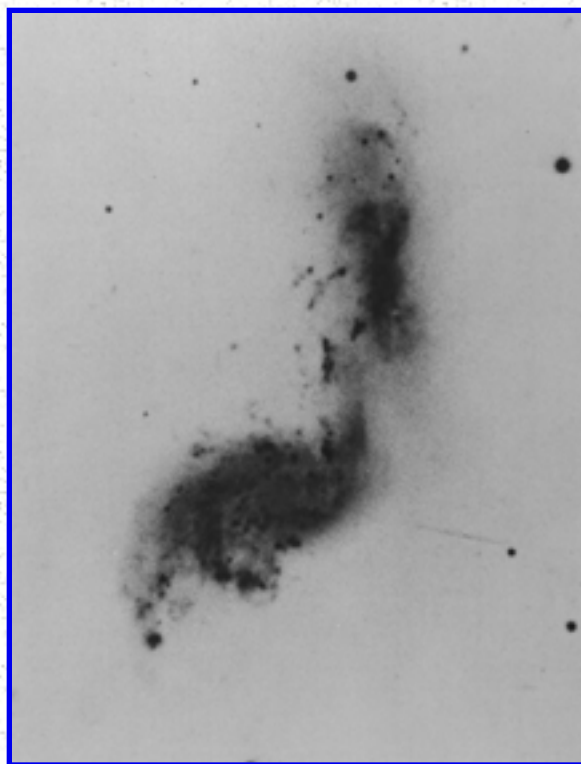
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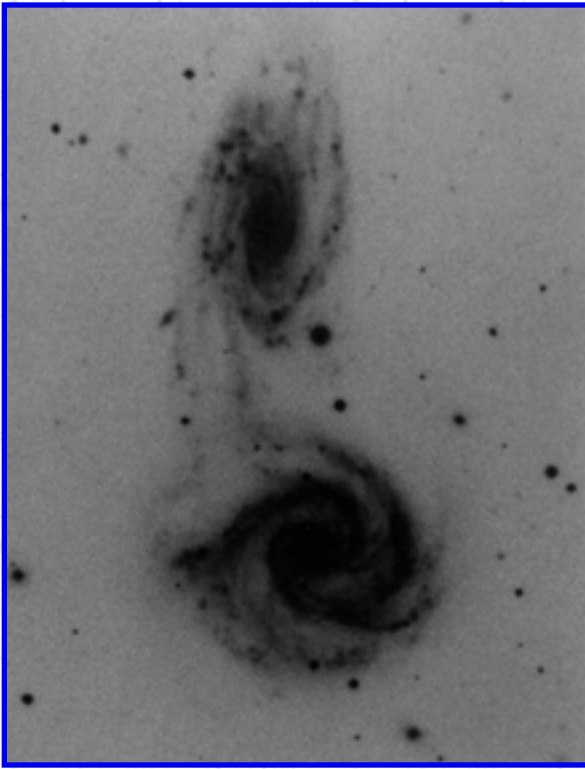
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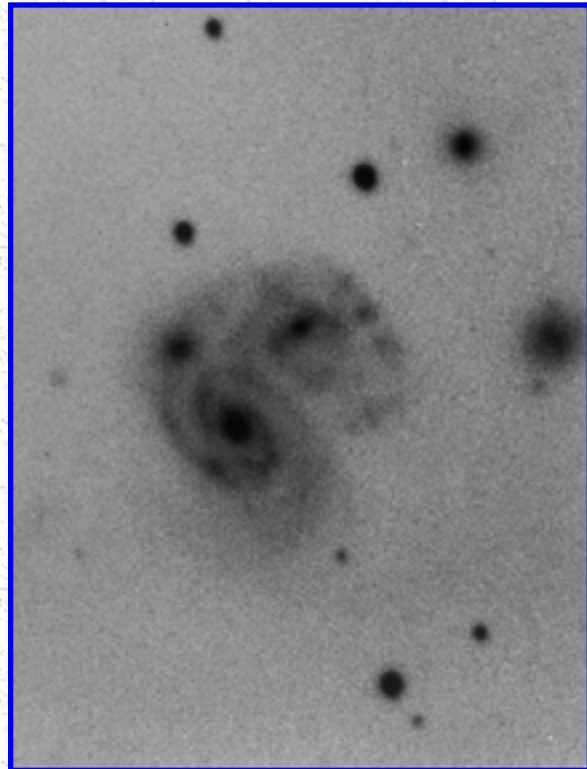
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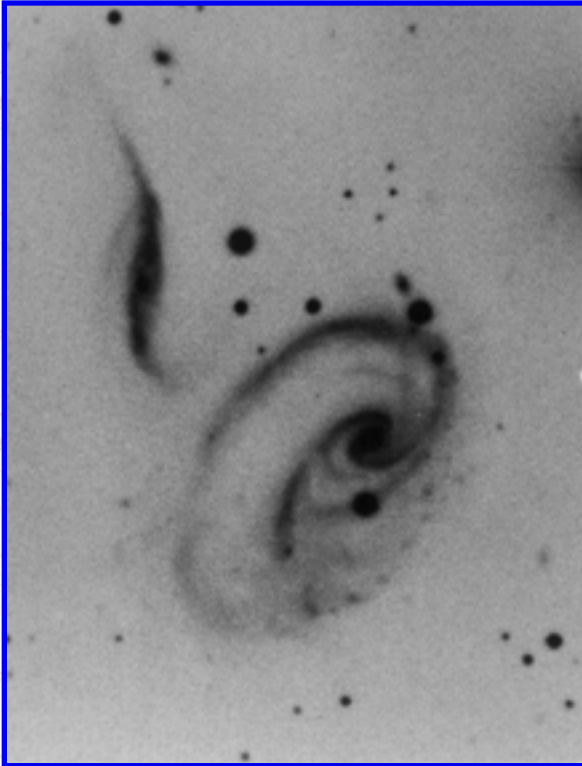
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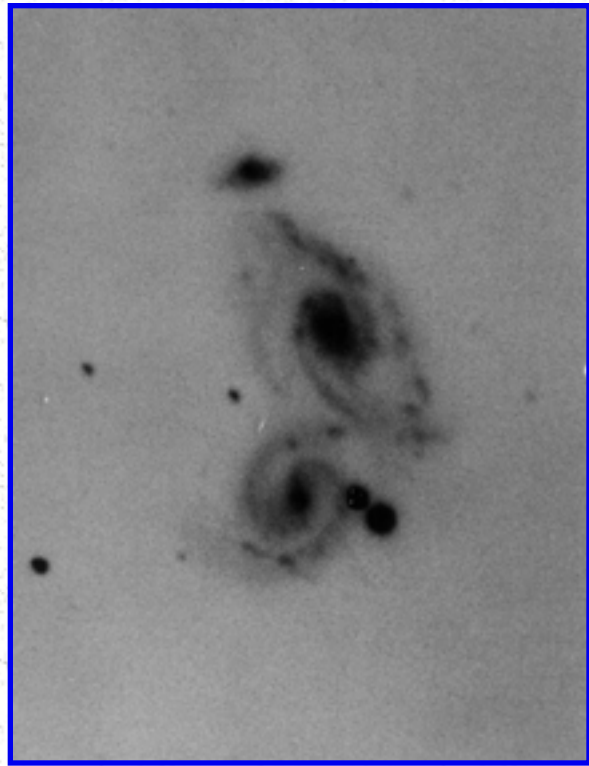
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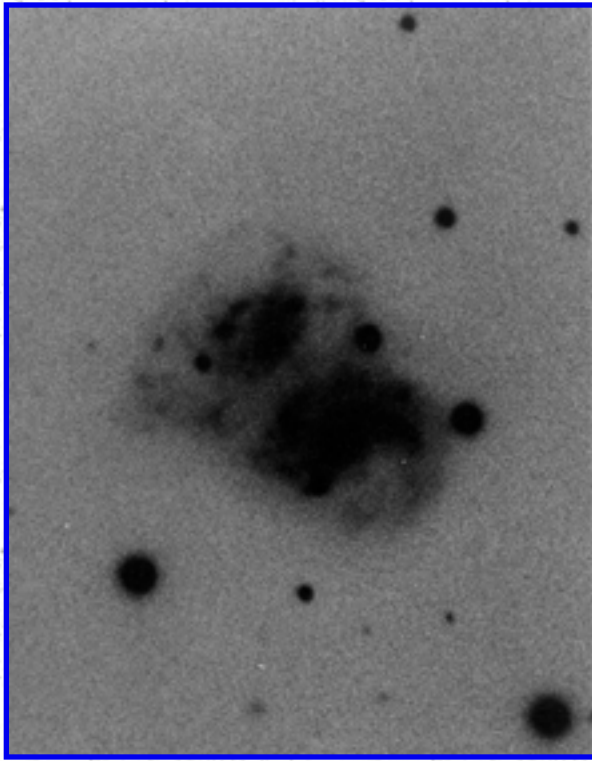
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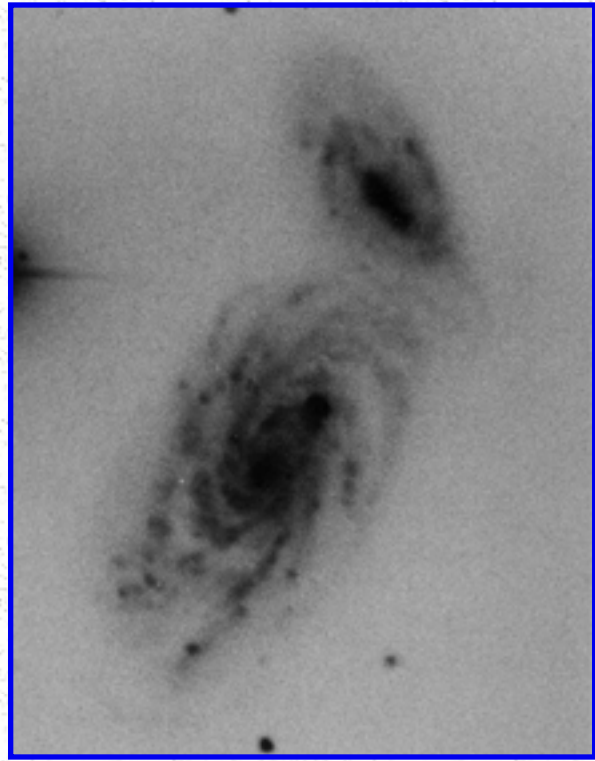
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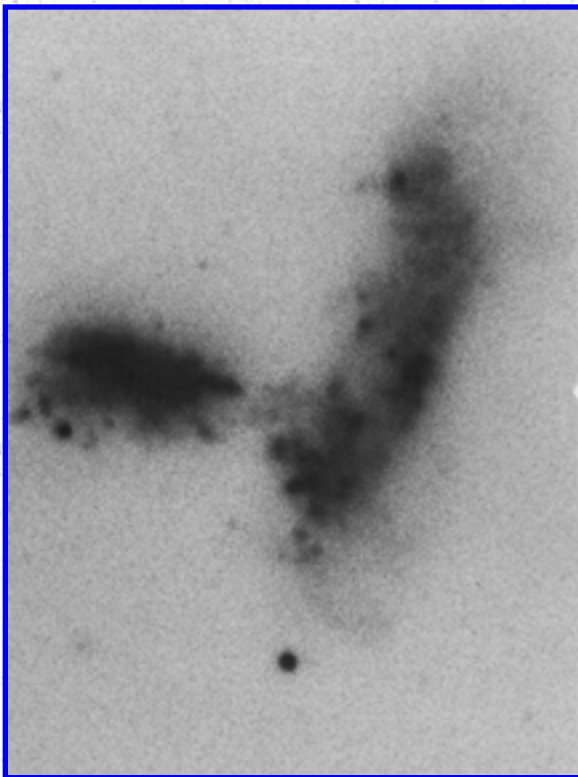
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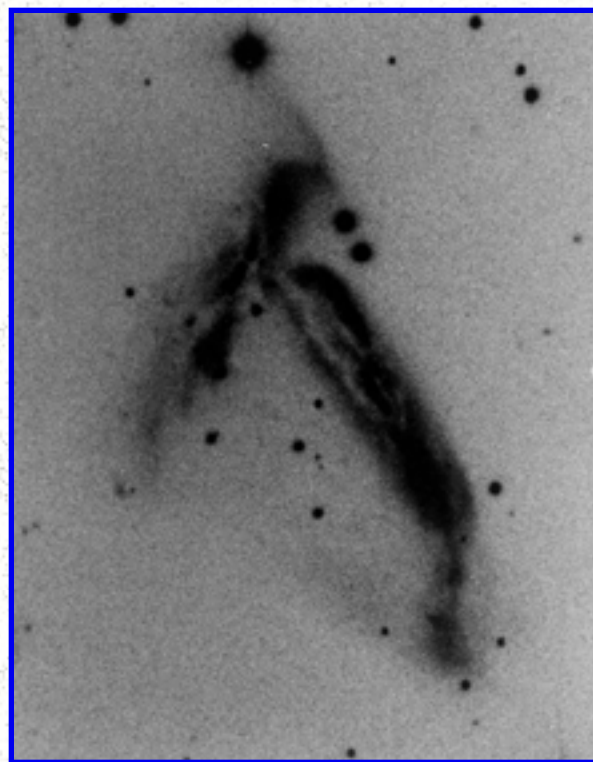
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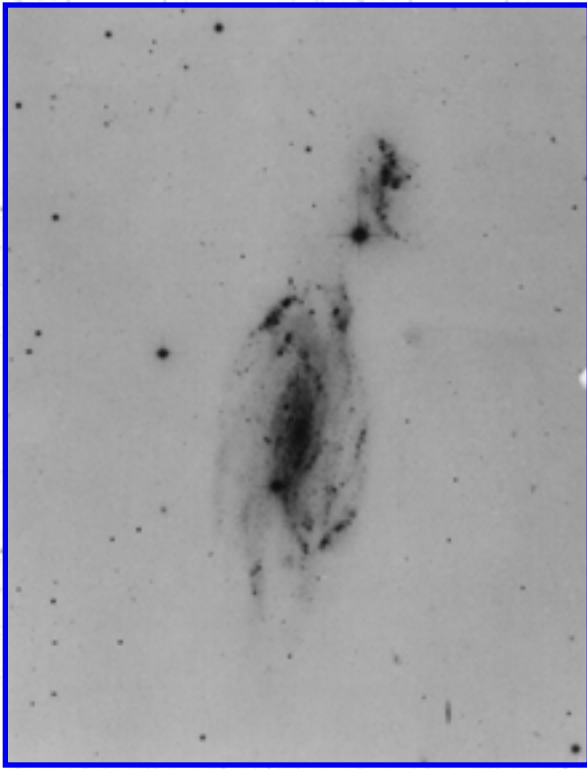
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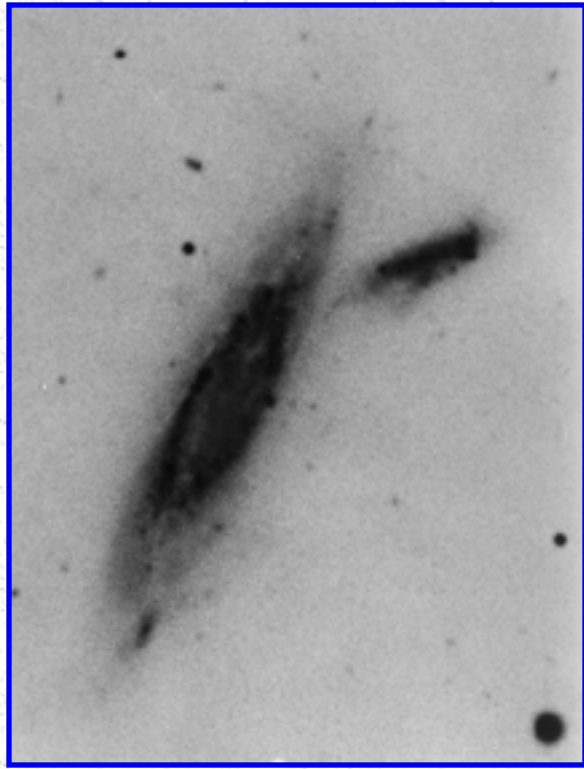
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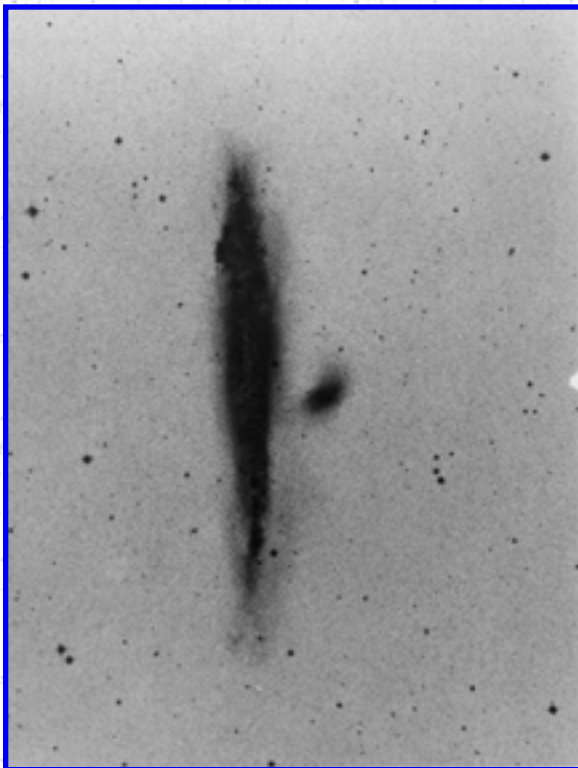
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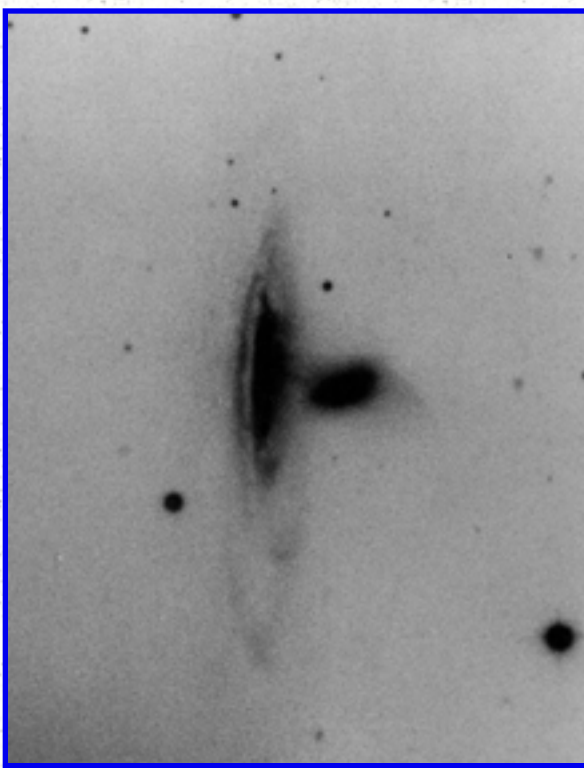
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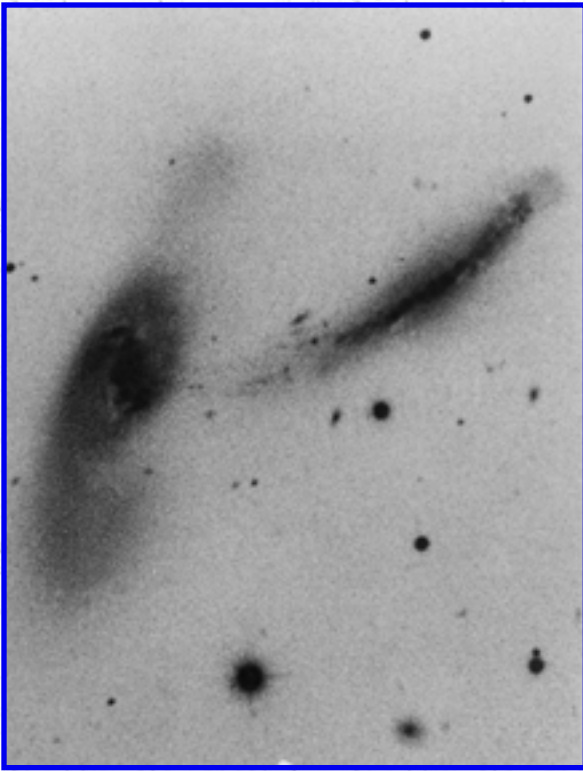
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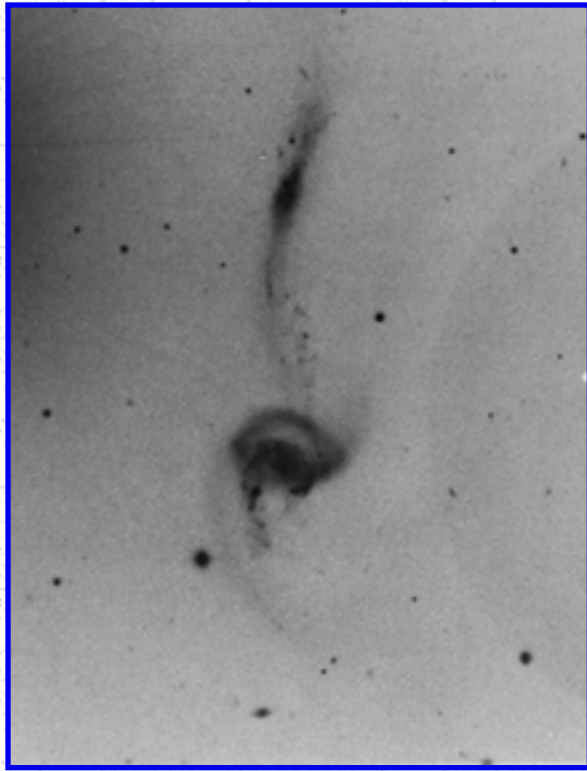
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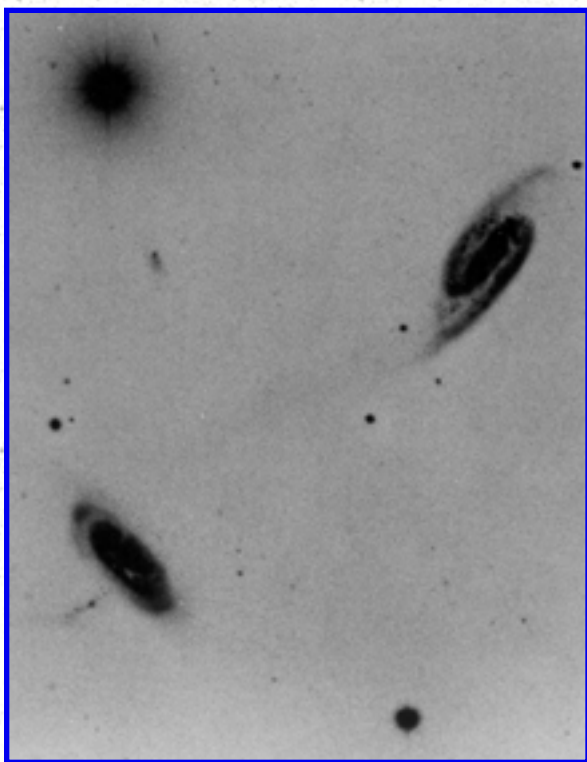
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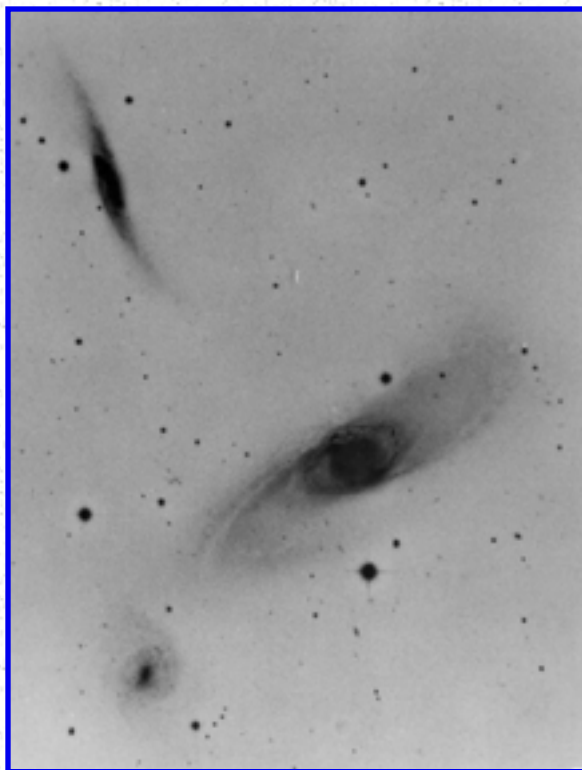
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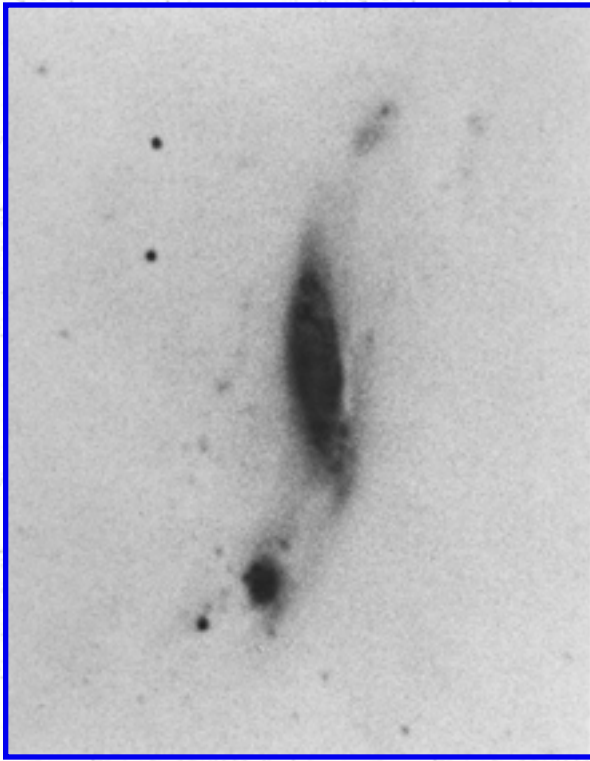
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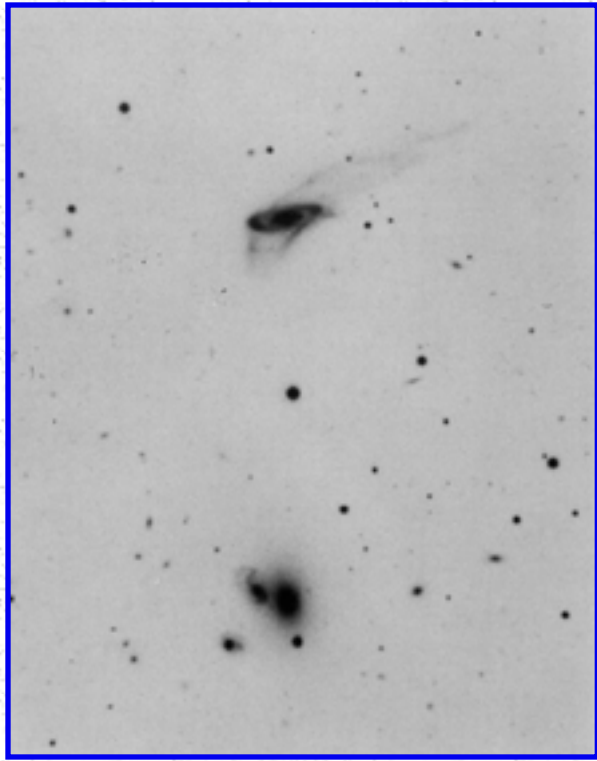
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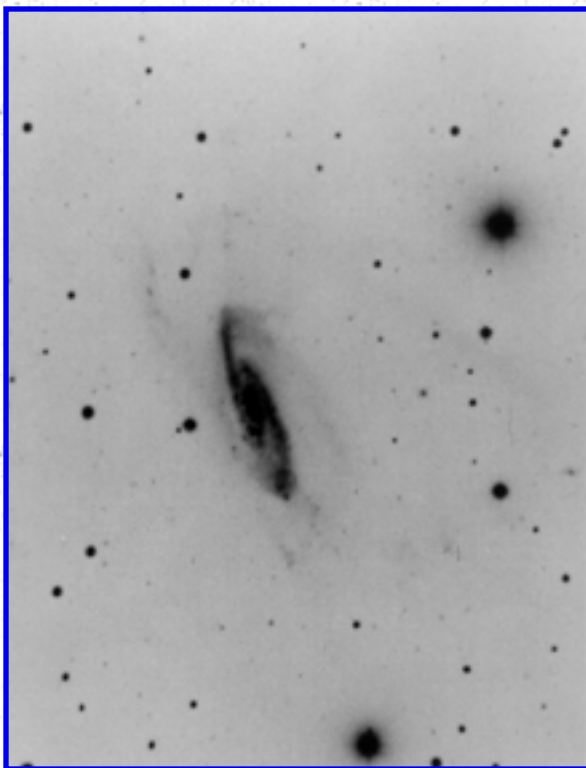
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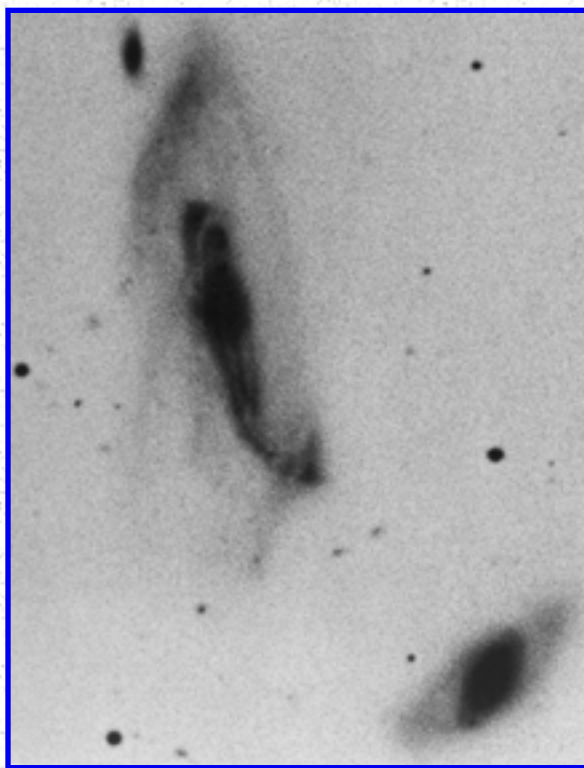
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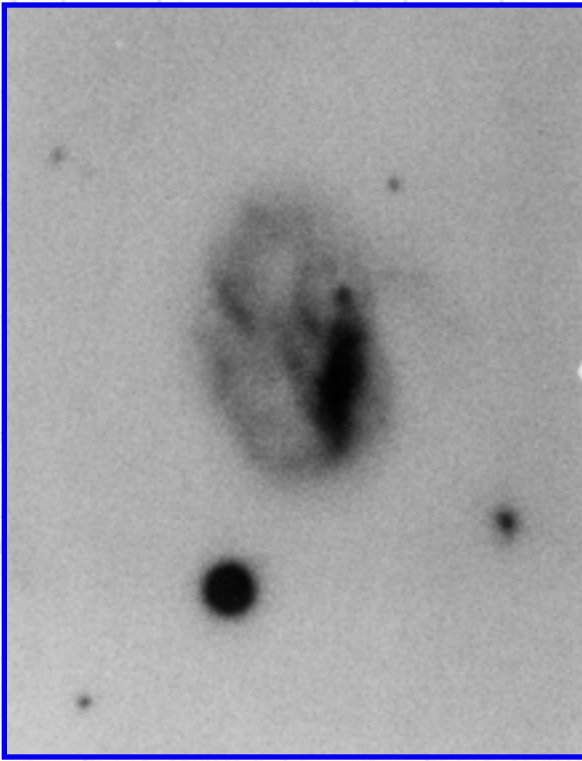
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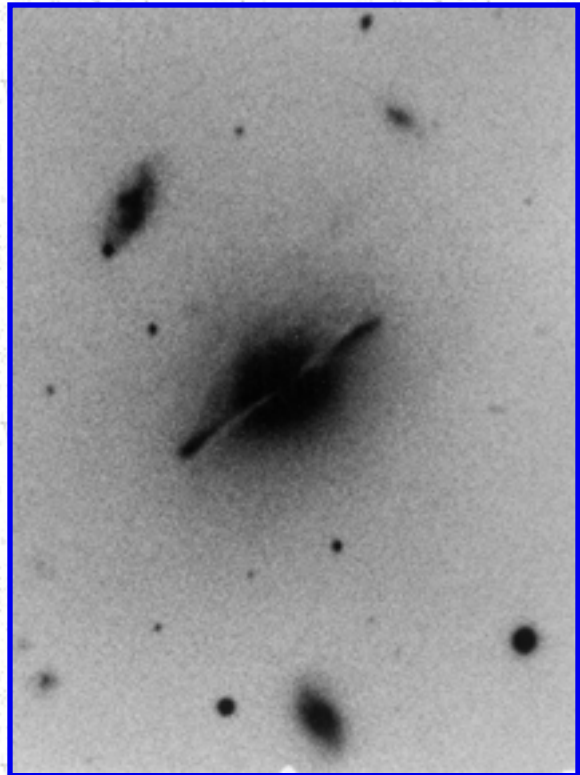
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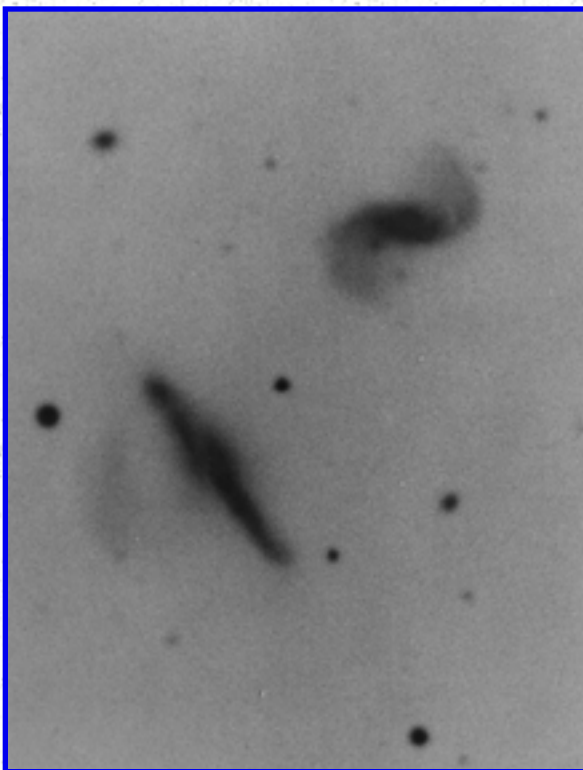
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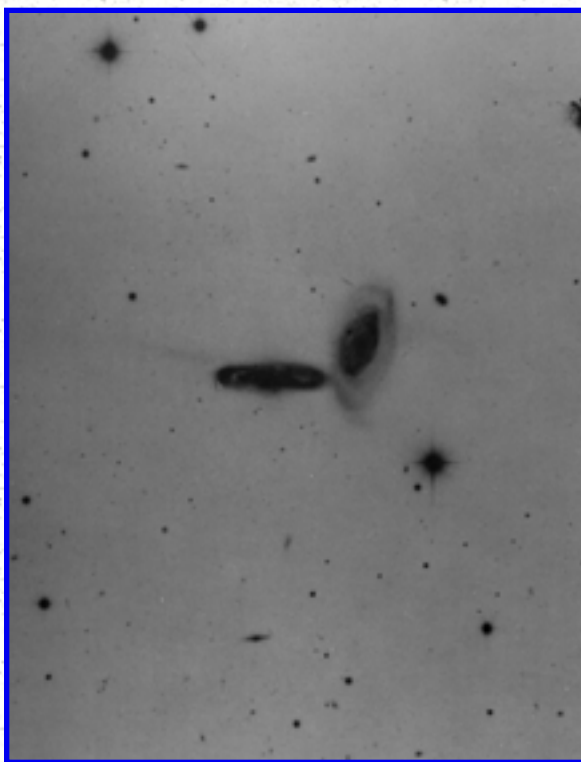
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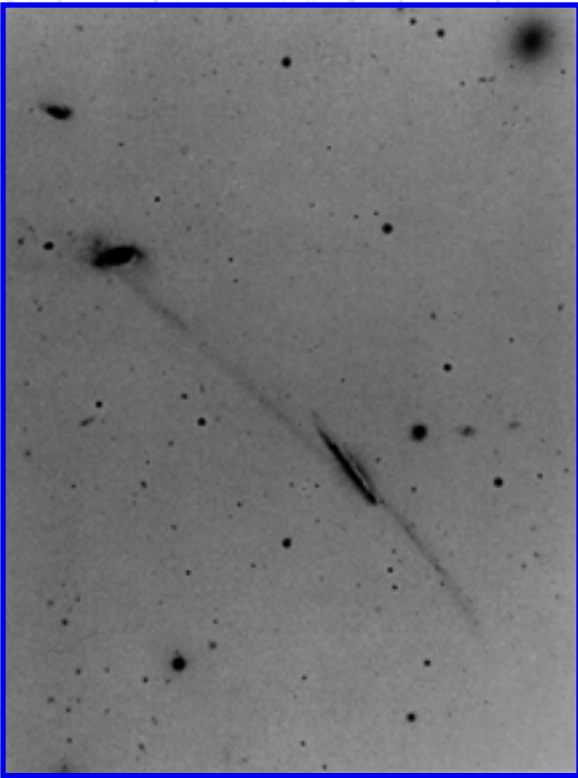
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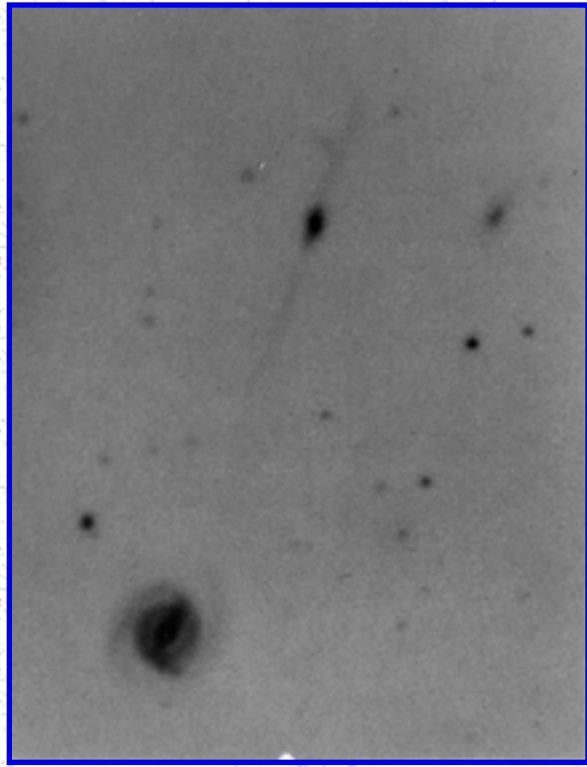
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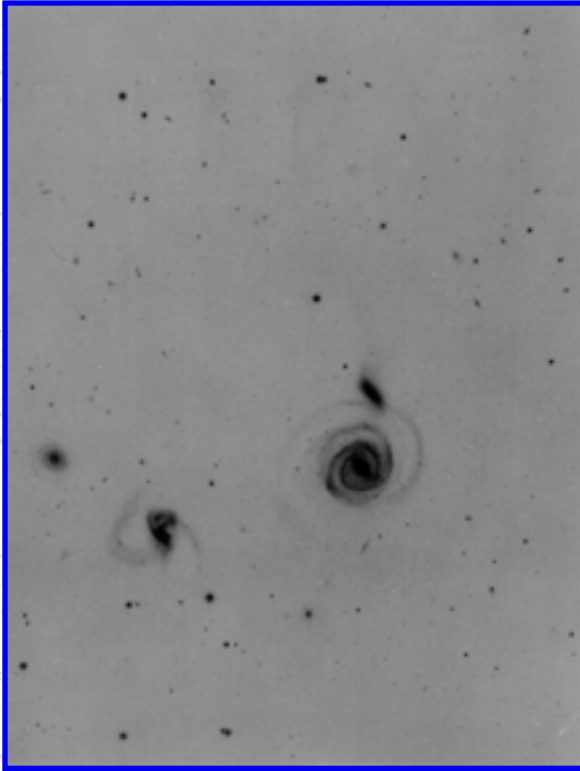
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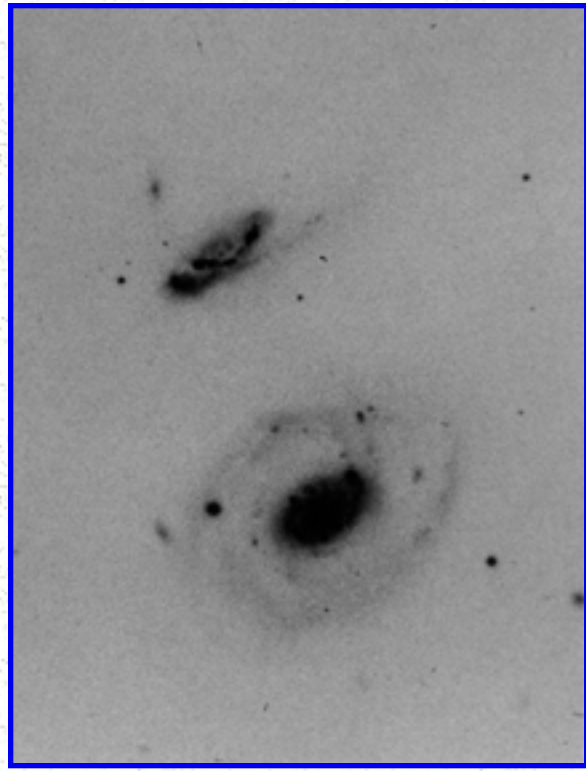
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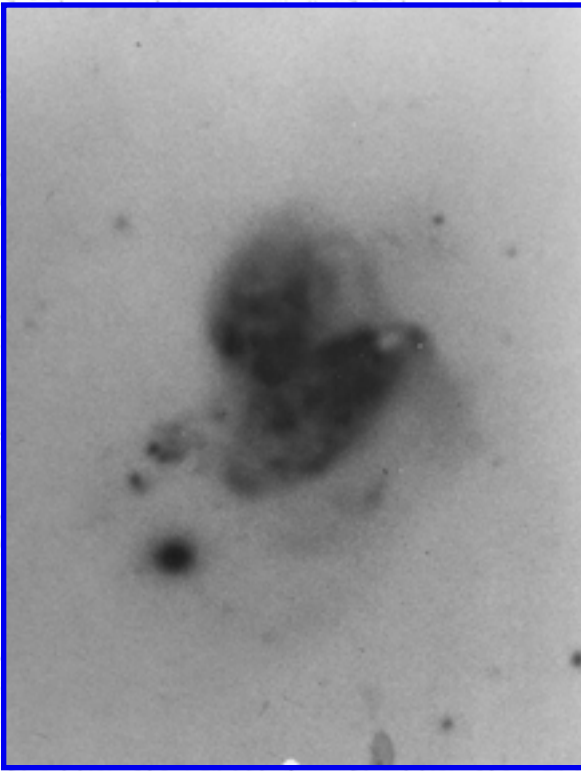
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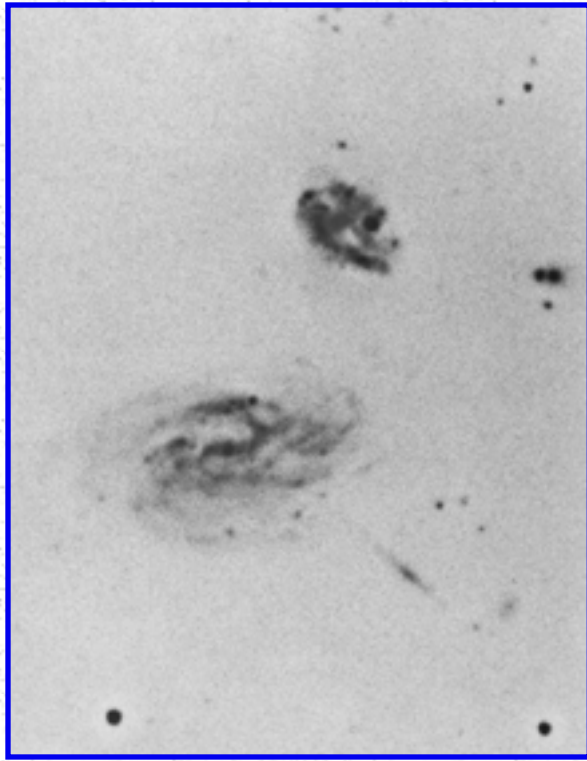
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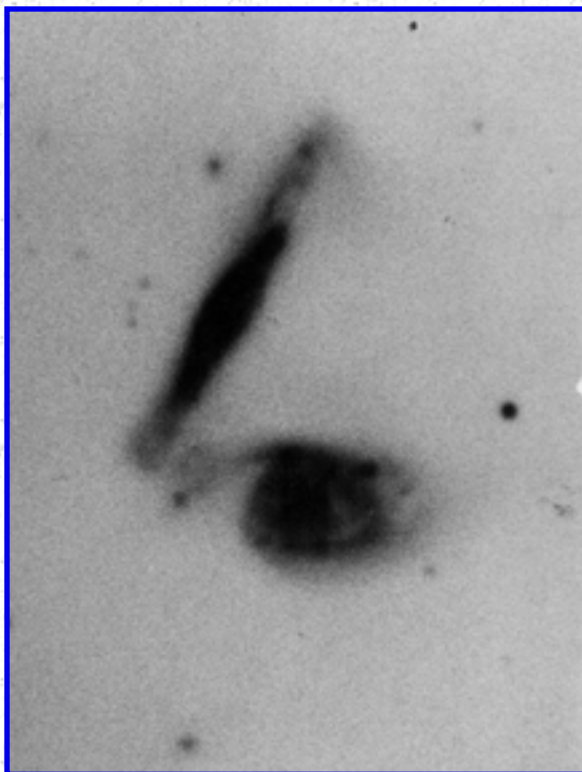
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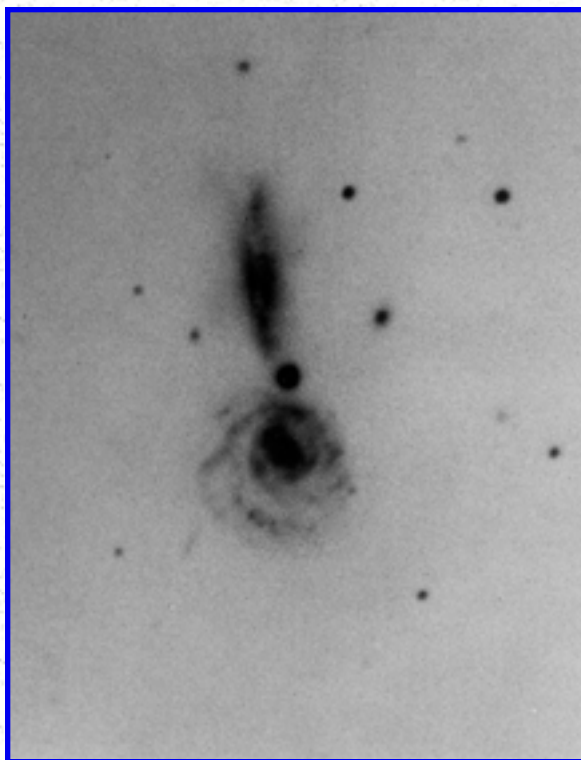
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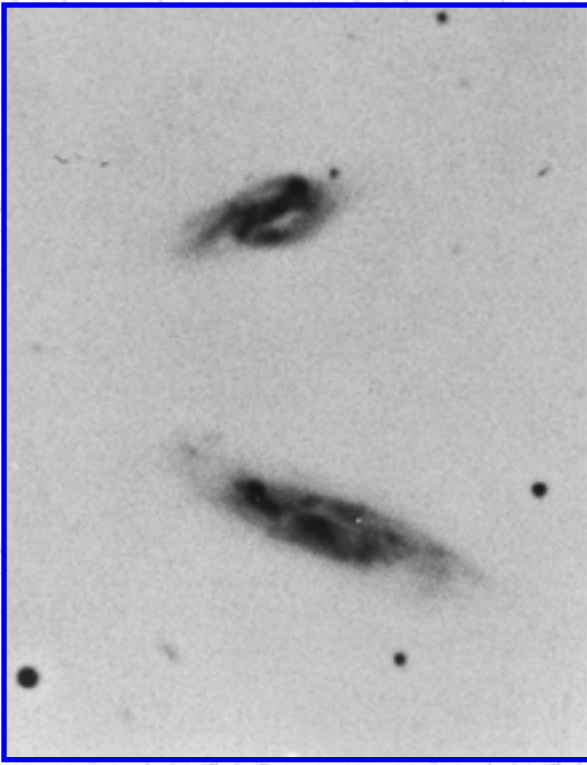
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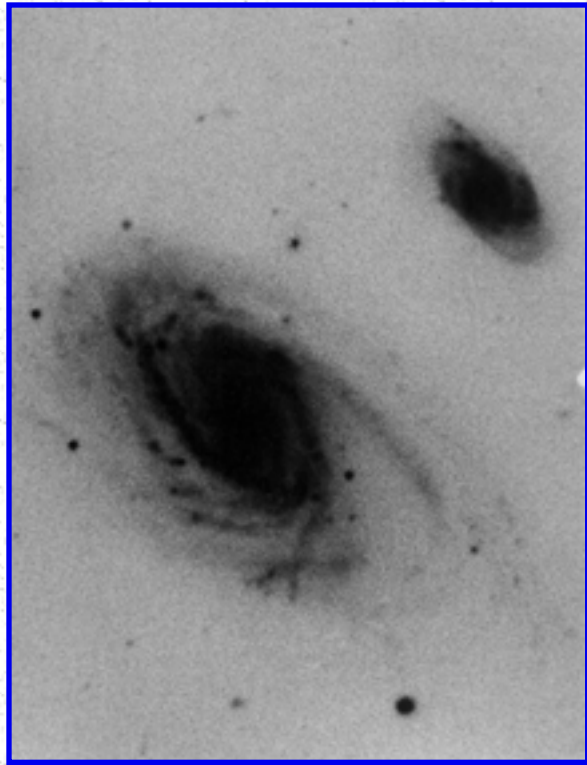
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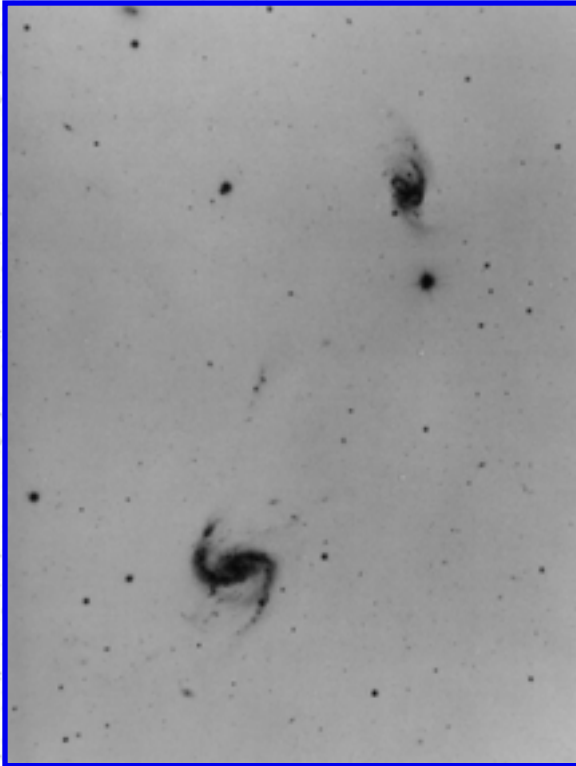
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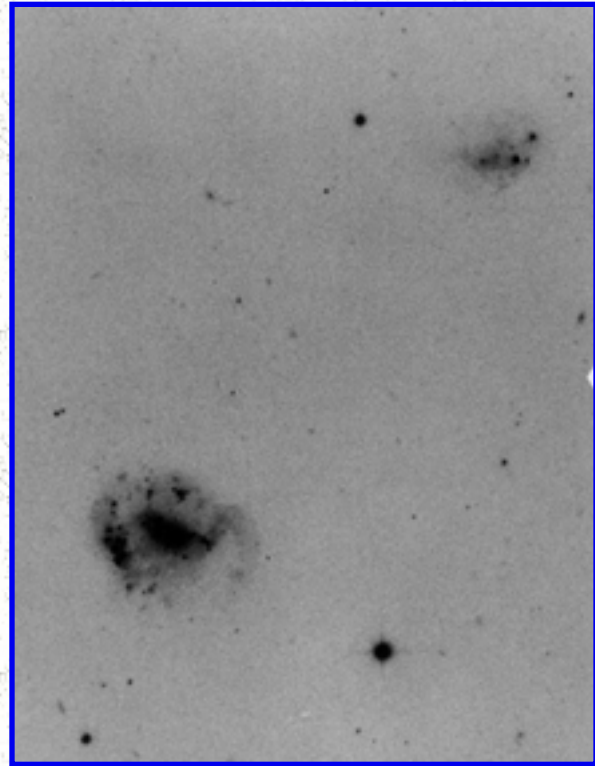
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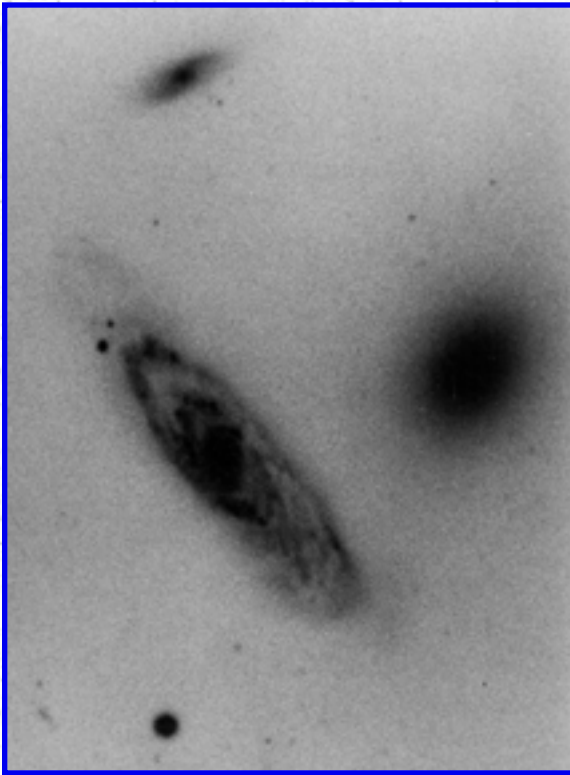
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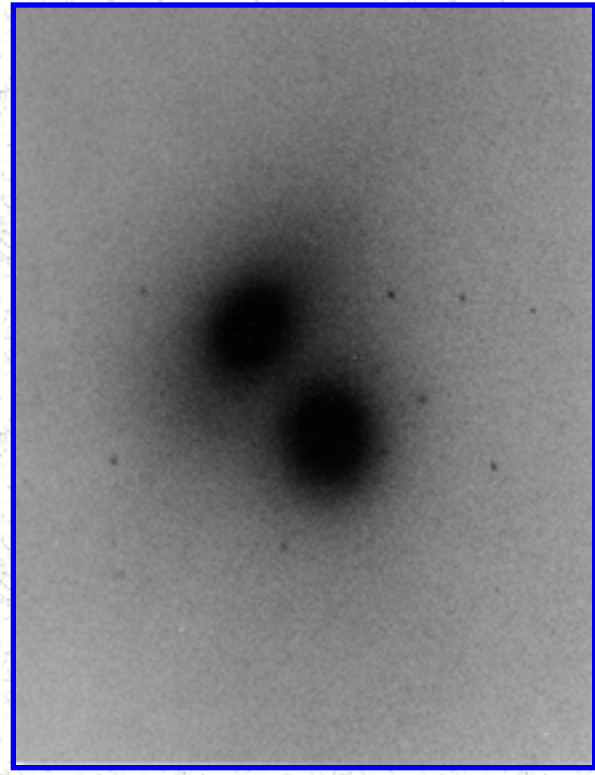
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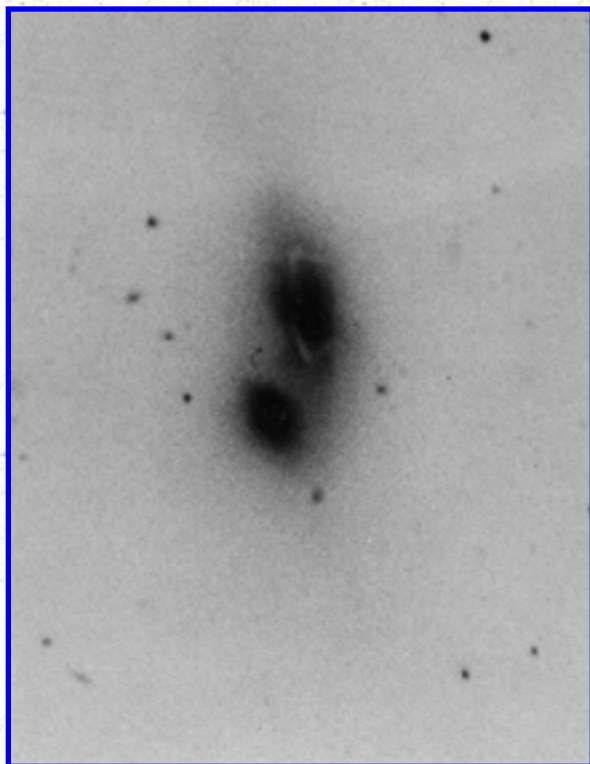
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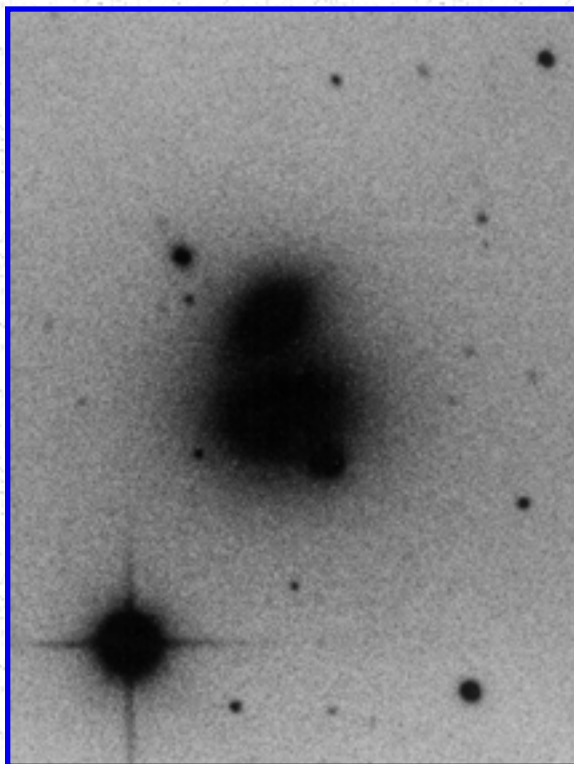
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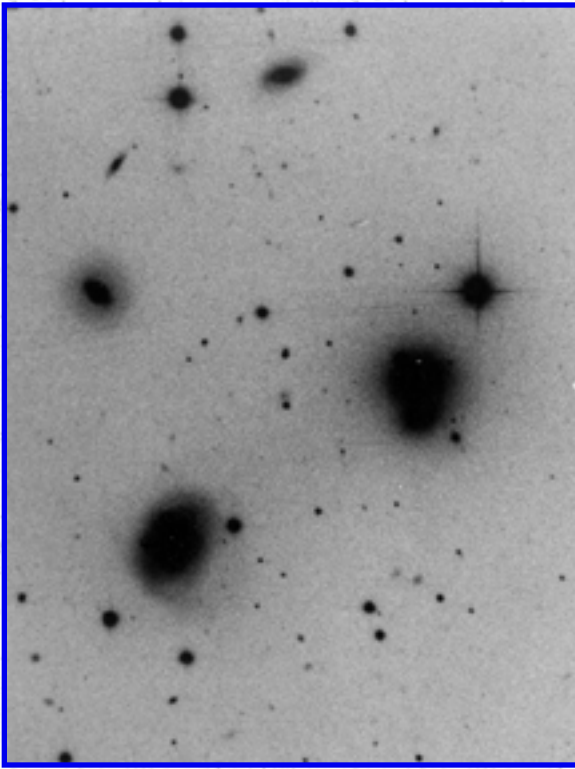
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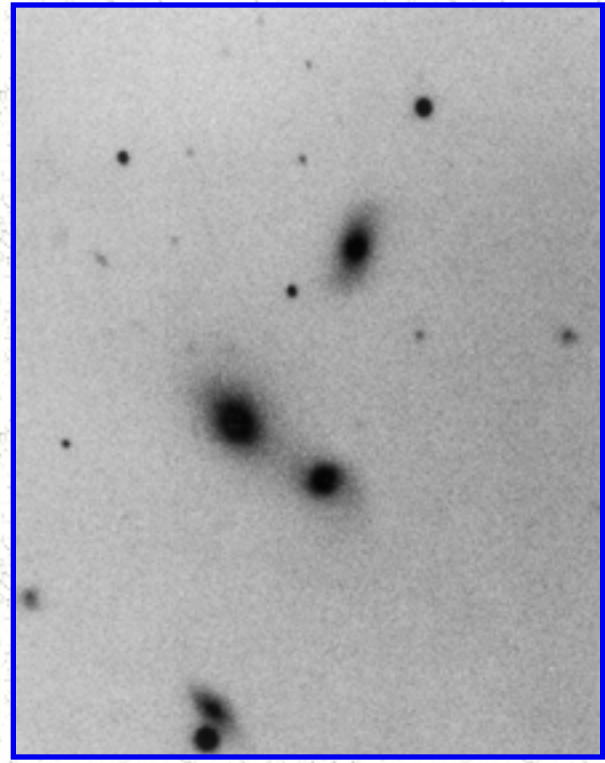
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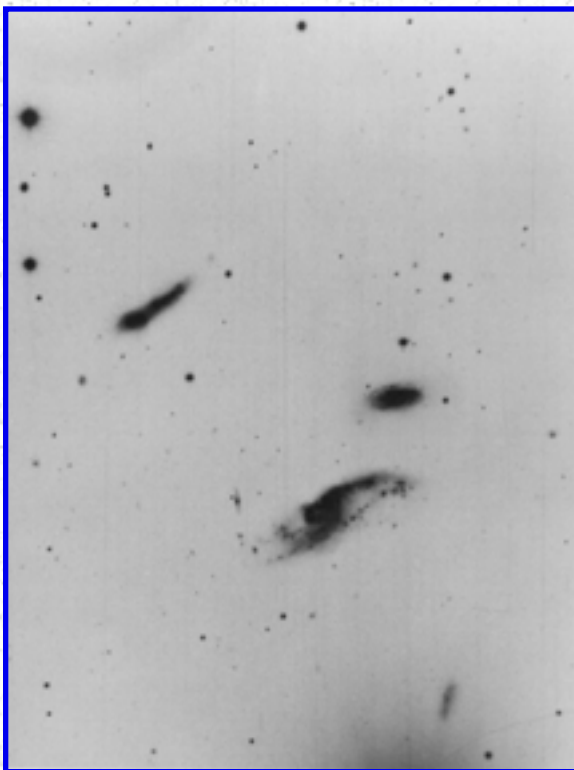
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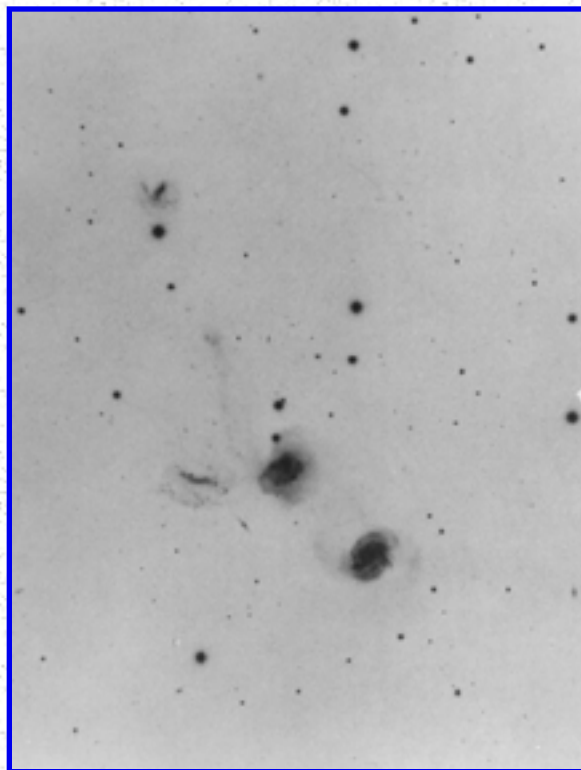
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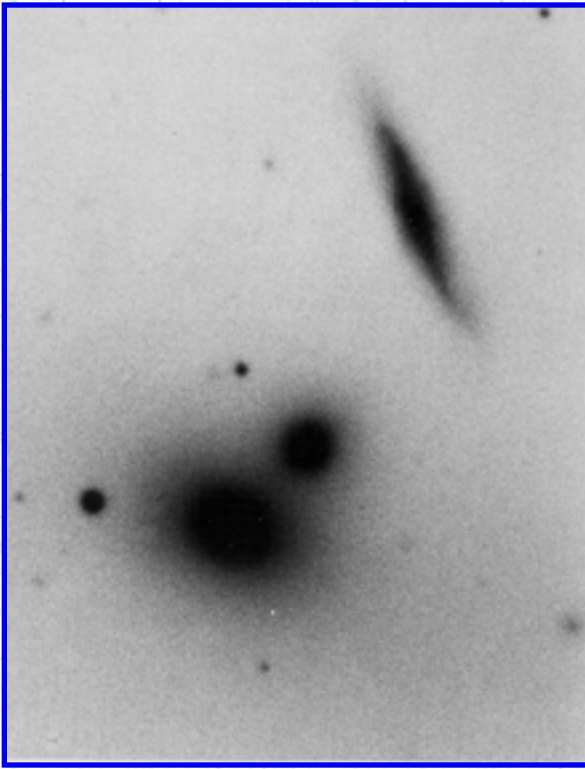
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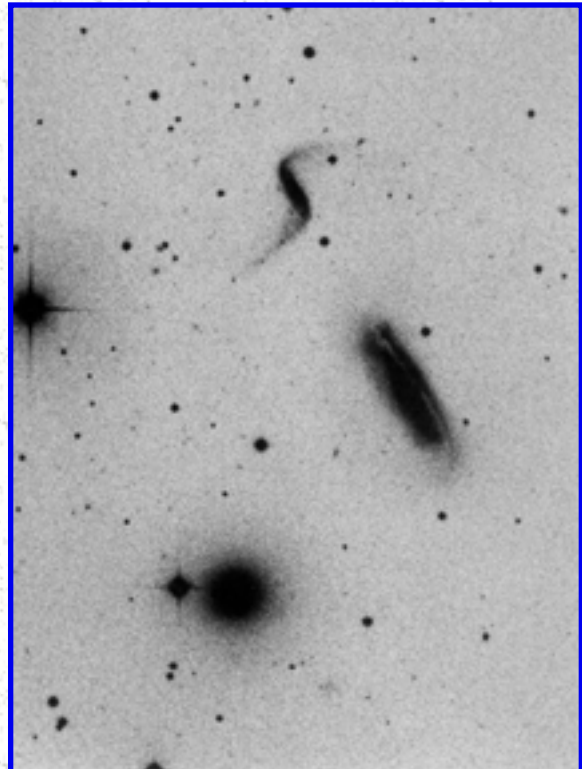
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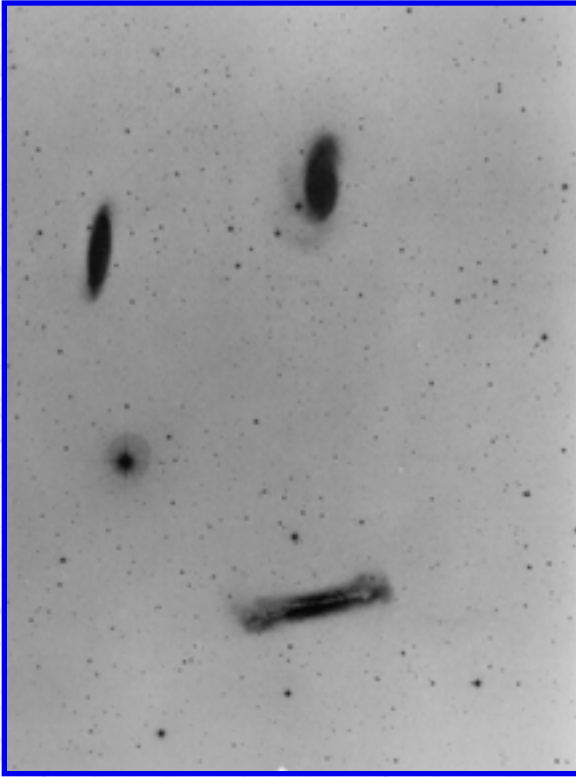
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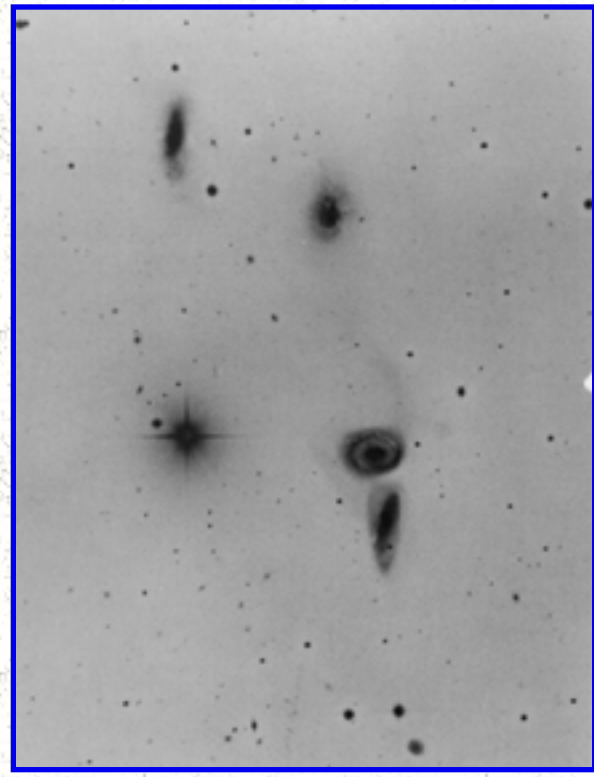
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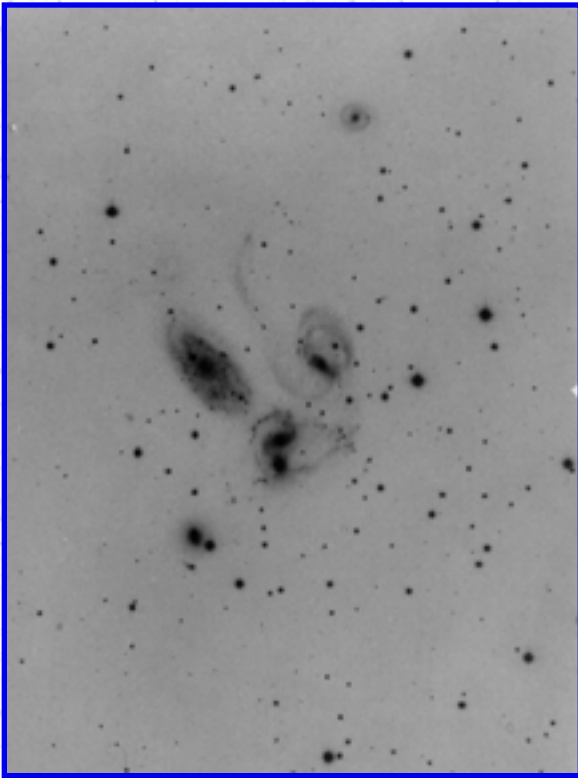
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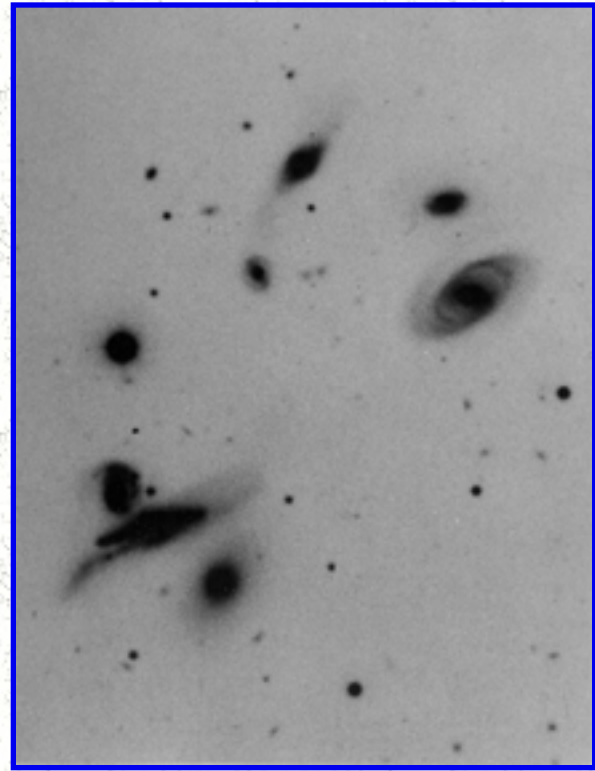
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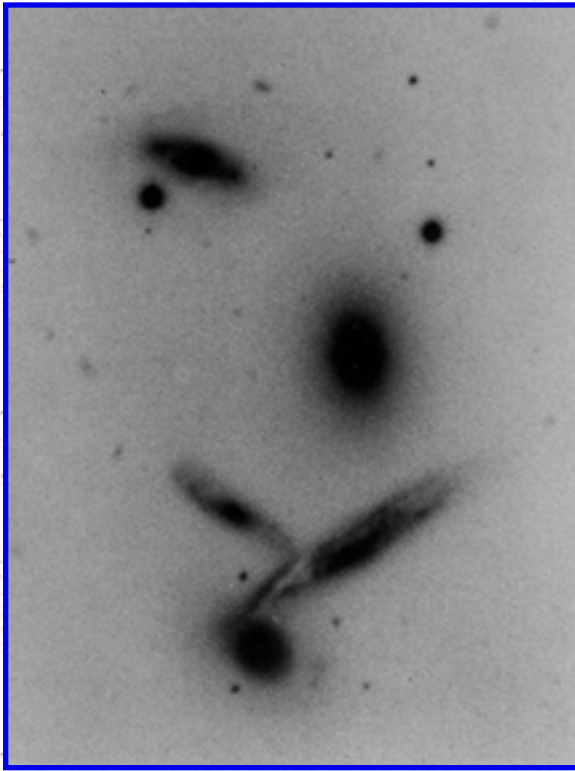
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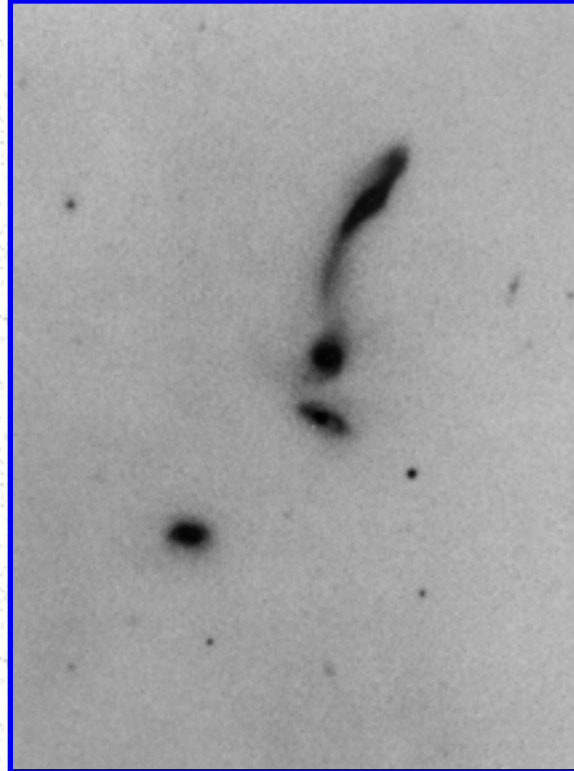
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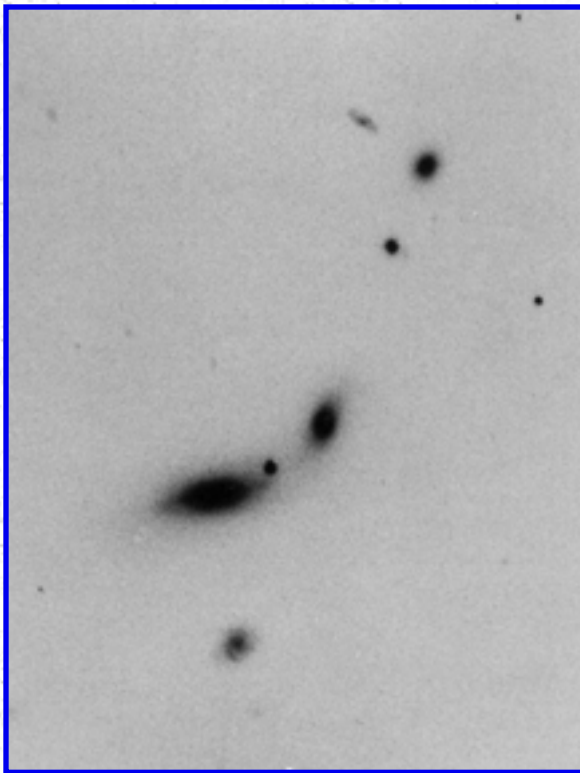
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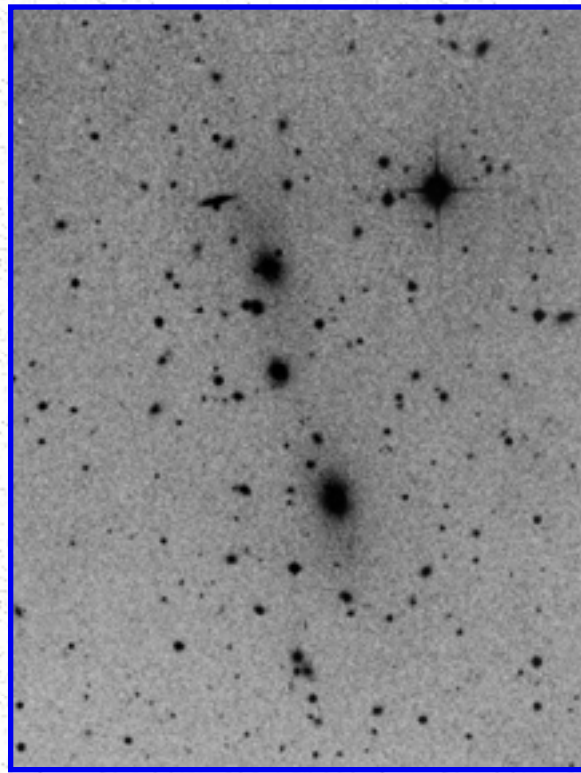
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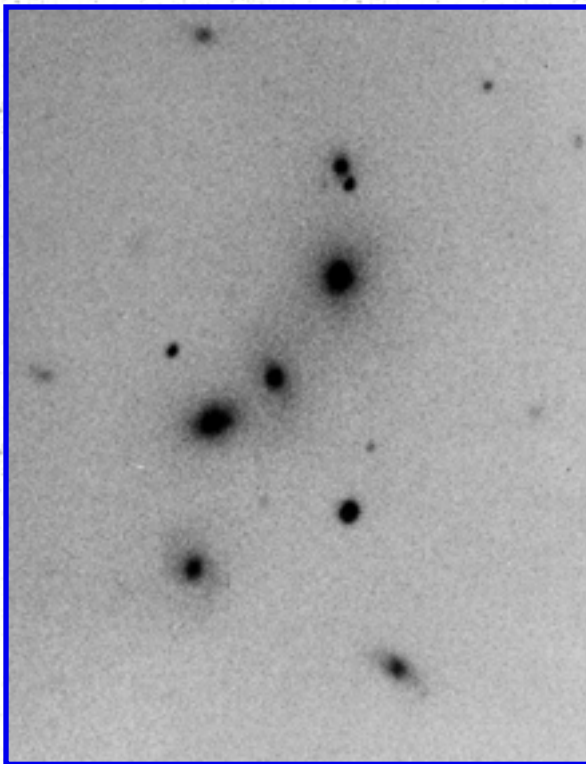
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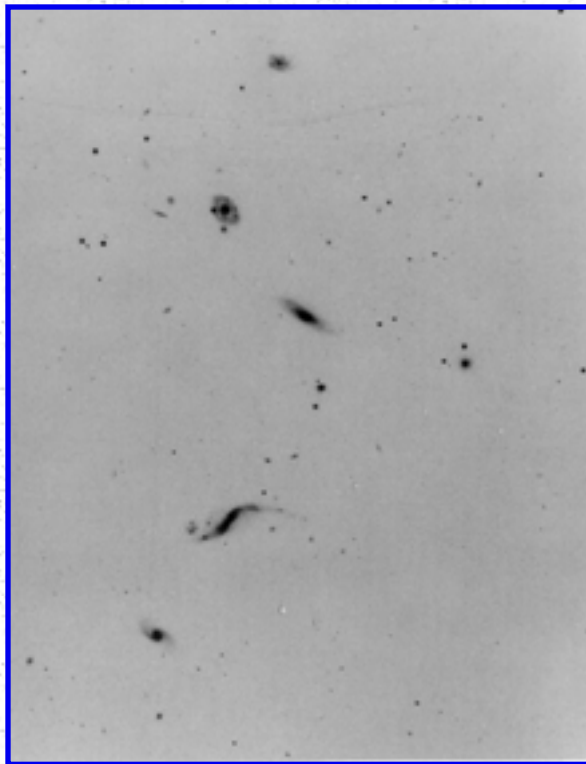
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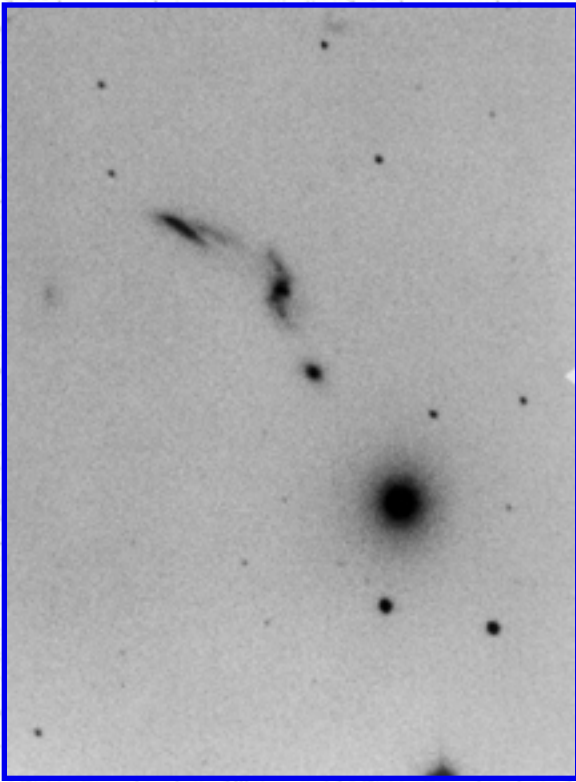
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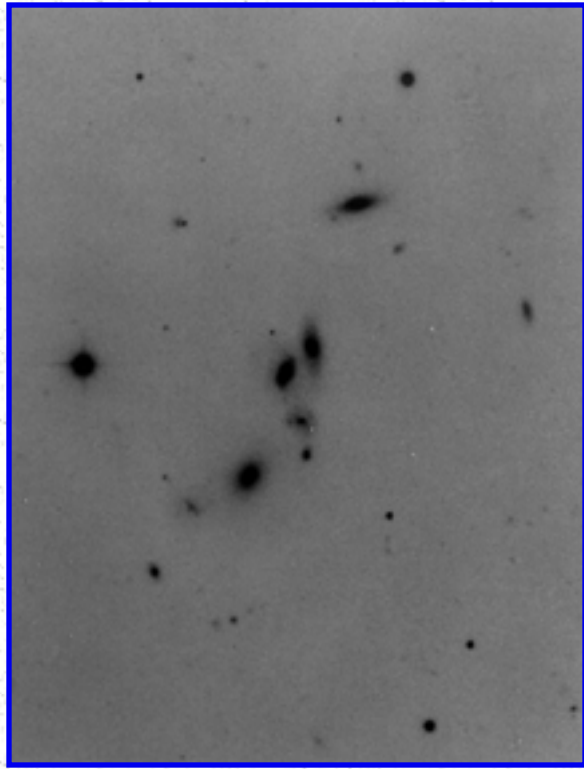
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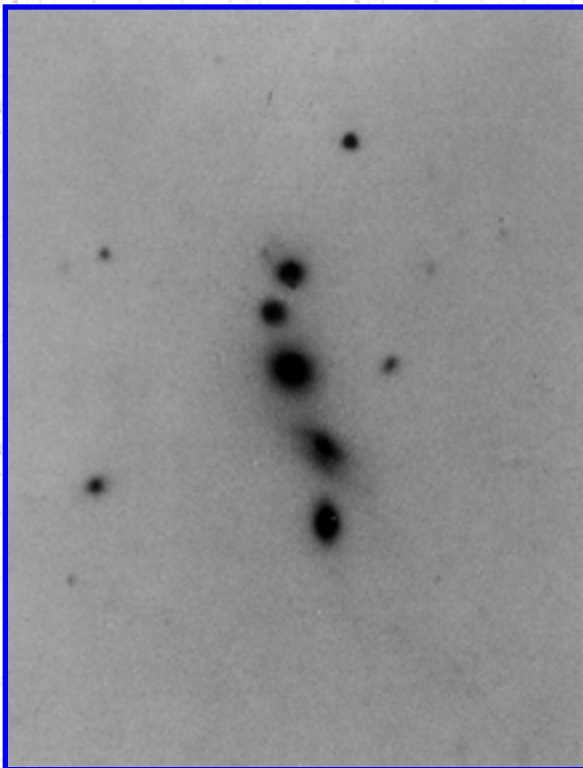
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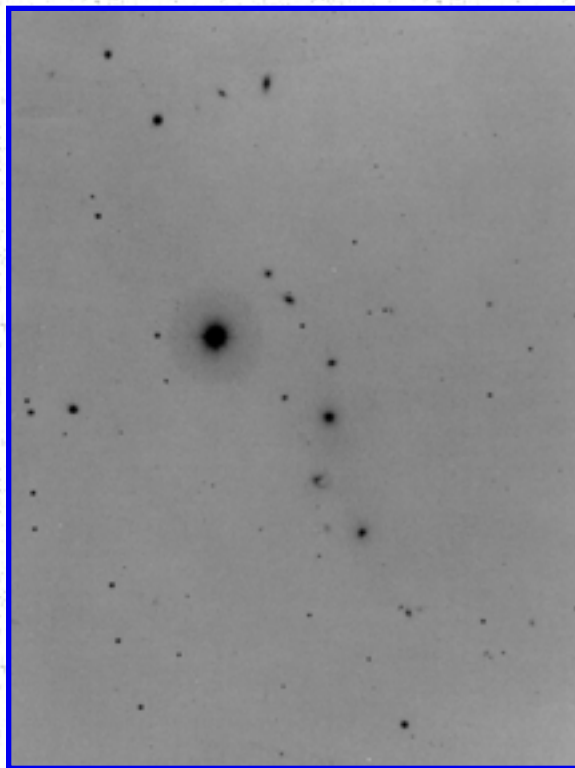
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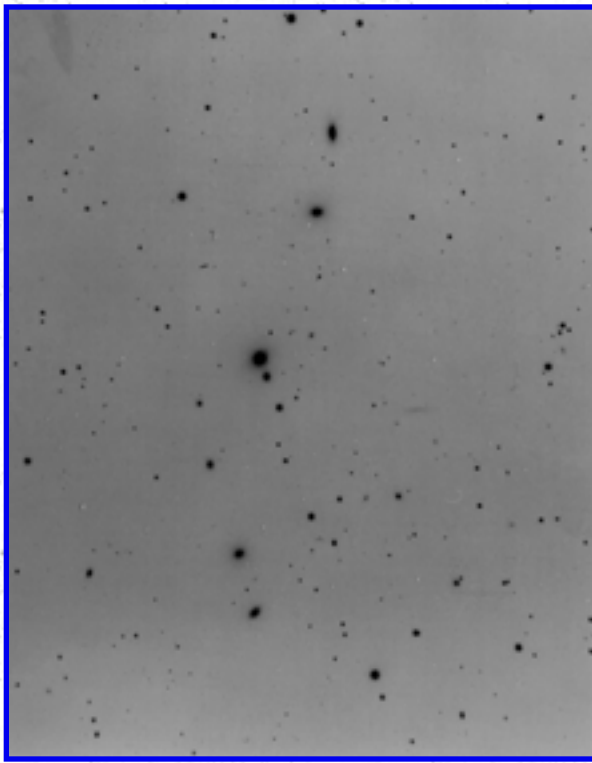
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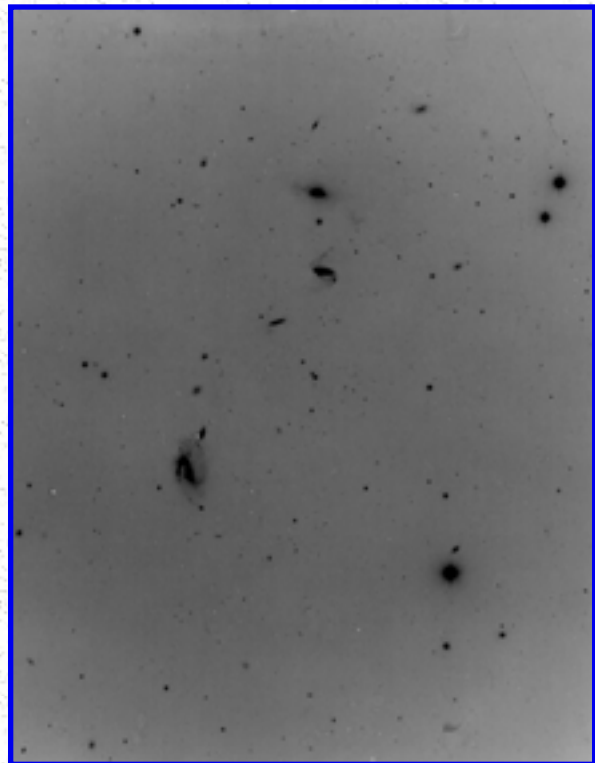
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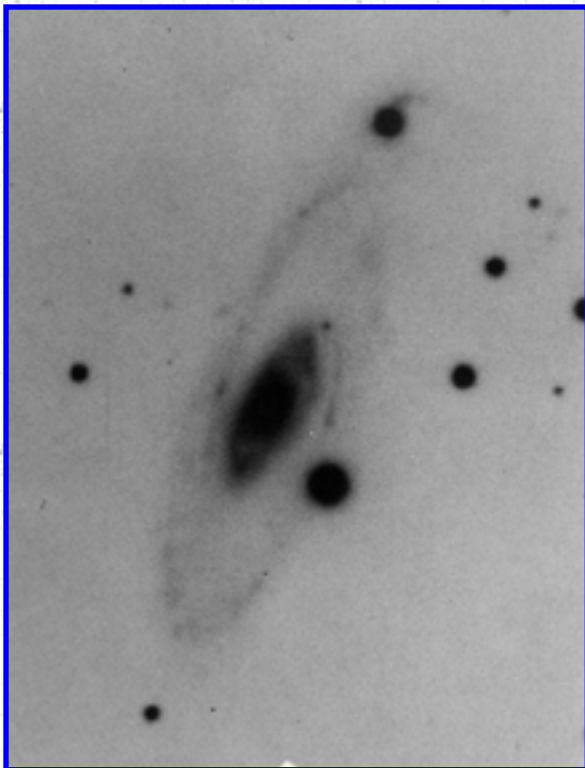
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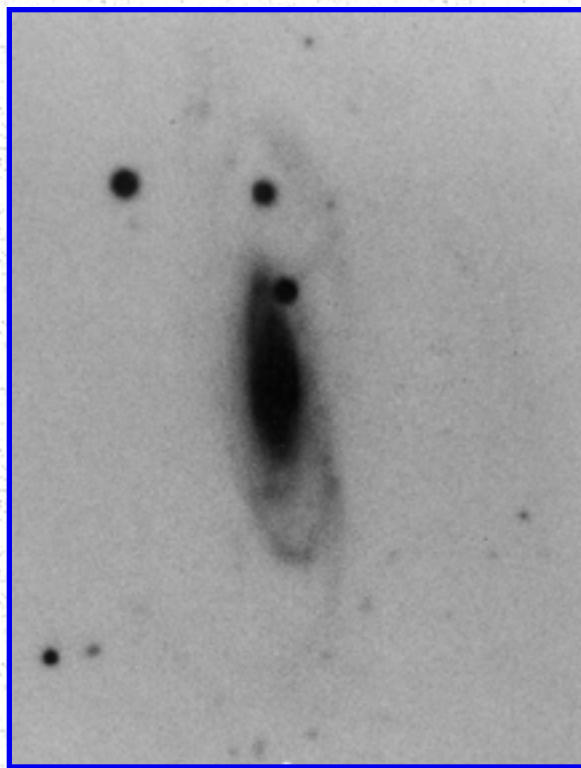
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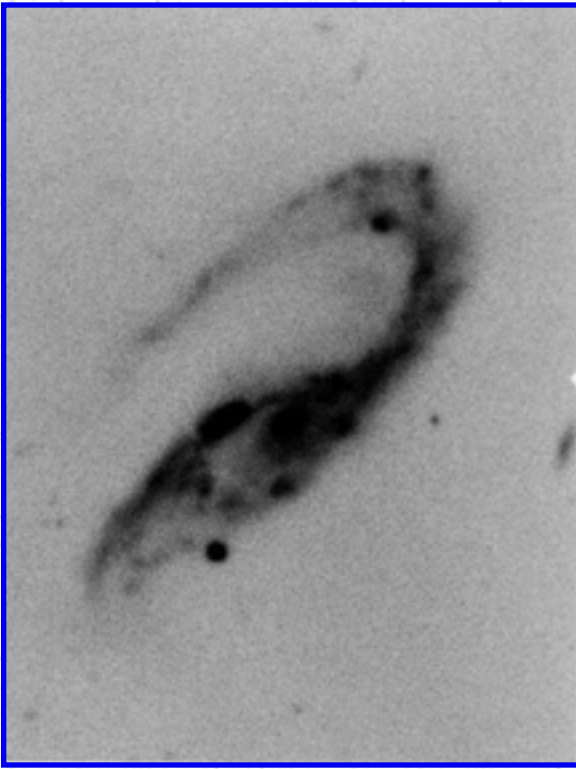
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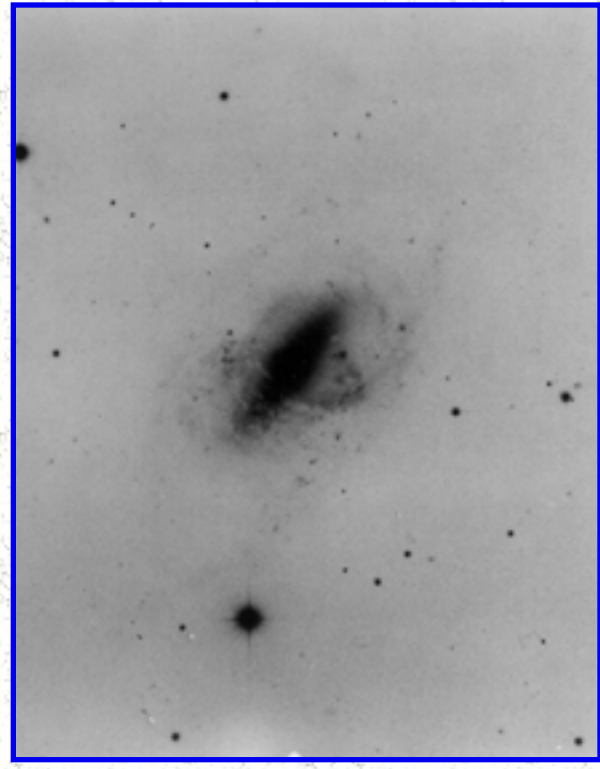
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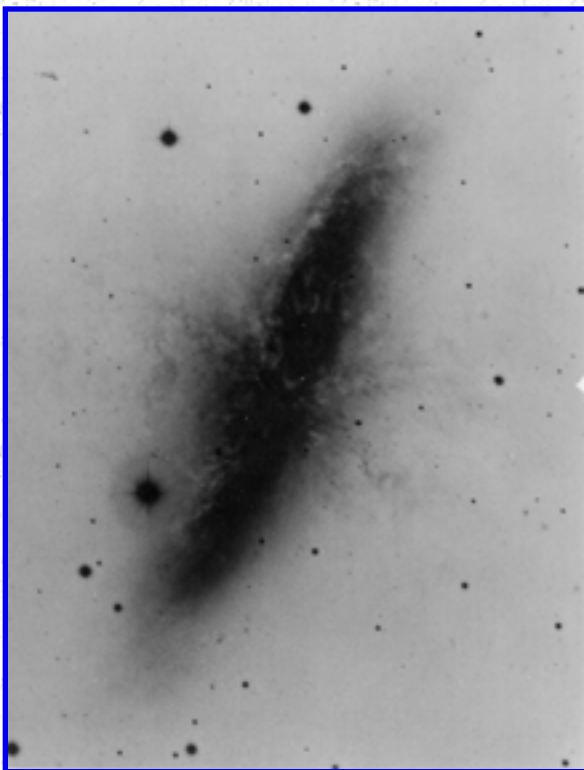
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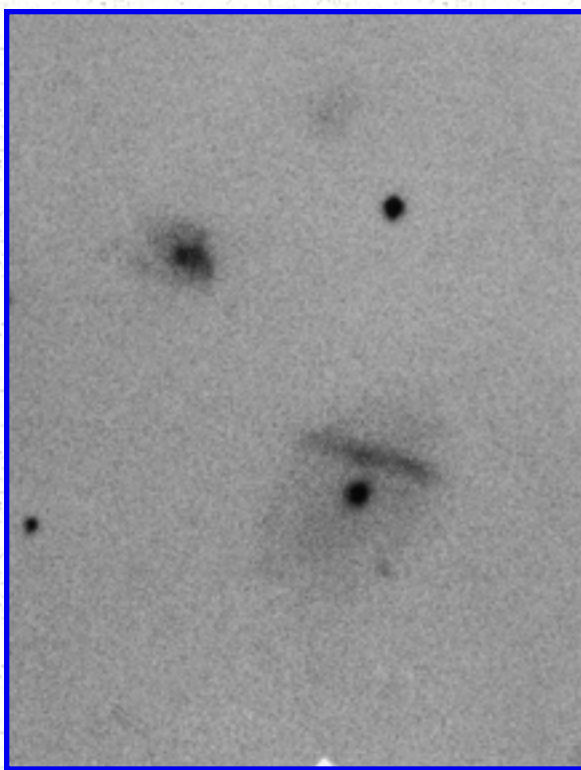
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