A PROPOSED PROGRAM OF OBSERVATIONS OF EXTRAGALACTIC X-RAY SOURCES

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Abstract. It is proposed to carry out an observational test of the hypothesis that active galactic nuclei contain a massive black hole, surrounded by an accretion disk as an energy source. The observational program included 64 objects, selected according the Aldrovandi's model.

1. Definition of the Problem

This program is based on the contention that active galaxies' nuclei contain a massive relativistic object (a black hole), surrounded by an accretion disk. The program is stimulated mainly by the paper of Shields (1986).

Rees (1984) made a detailed review of models of active nuclei, containing a black hole. Subsidiary evidence in favour of our contention was provided by Davidson (1972) and Shields and Oke (1975), who explained the emission lines in the spectra of Seyfert's galaxies and quasars as caused by UV radiation-induced photoionization, generally an extrapolation of the power-law spectrum. Pravdo and Marshall (1984) pointed to the accretion disk around the relativistic object as a source of soft X-ray emission in active nuclei. Ferland and Osterbrock (1985) proved that in 3C 192 and 3C 223, narrow emission line galaxies, photoionization is induced by an X-ray source.

2. Observational Test in the Optical Range in the Case of Disc Accretion Onto a Black Hole in the Active Galactic Nuclei

Disk accretion onto black hole of the accretion rate $\dot{M}_a$ is known to cause luminosity L about $10^{46}\,\dot{M}_{\odot}$ erg s^{-1}, where $\dot{M}_{\odot}$ is the accretion rate in units solar masses yr^{-1}. Besides, Eddington's luminosity of an object of mass M is L_{Edd} about $10^{46}\,M_8$ erg s^{-1}, where M_8 is the mass of the object in units 10^8 solar masses. These two estimations indicate that luminosities of the active galactic nuclei can possibly be explained with accretion of matter onto black hole of mass $10^8\,M_{\odot}$ and accretion rate about $1\,M_{\odot}$ yr^{-1}.

(1) The ratio thermal/nonthermal energy, released as a result of the accretion is not defined, but if these are comparable and nonthermal energy is the consequence of the power-law spectrum $E_{\nu} = \nu^{\alpha}$, $\alpha = -1.2$, thermal energy then will be manifested as an excess in the near-ultraviolet, what is frequently observed (all Markarian galaxies in Table I).

(2) The dynamic time R/V_k at distances $100\,R_g$, where R is the distance from the

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TABLE I

Object	α_{1950}	δ_{1950}	z	V	Remarks
*Mrk 335	$00^h03^m45^s.2$	19°55′29″	0.025	13.85	Sy1
*III Zw 2	00 07 56.7	10 41 47	0.089	15.40	Sy1, radio
Mrk 348	00 46 04.9	31 41 04	0.014	14.59	Sy2, radio, N 262, U 499
I Zw 1	00 50 57.8	12 25 20	0.061	14.03	Sy1, U 545, PHL 3072
*Mrk 352	00 57 09.1	31 33 28	0.015	14.81	Sy1
II Zw 1	01 19 26.5	−01 18 05	0.054	15.17	Sy1, MCG 0–40–98
Mrk 573	01 41 22.9	02 05 56	0.017	14.07	Sy2, rad, U 1214, 0–5–33
Mrk 590	02 12 00.4	−00 59 57	0.027	13.81	Sy1, rad, N 863, U 1727
Mrk 1040	02 25 16.5	31 05 18	0.016	14.74	Sy1, N 931, U 1935
Mrk 595	02 38 55.8	06 58 27	0.028	14.69	Sy1
Mrc 372	02 46 31.4	19 05 50	0.031	14.81	Sy1, IC 1854
3C 120	04 30 31.6	05 14 59	0.033	15.05	Sy1, rad, II Zw 14, U 3087
Mrc 618	04 34 00.0	−10 28 36	0.035	14.51	Sy1, rad, MCG–2–12–45
NGC 1685	04 50 03.9	−03 01 53	0.014	15.18	Sy2, MCG–1–13–32
*Akn 120	05 13 37.9	−00 12 16	0.033	13.92	Sy1, U 3271, 0–14–18
NGC 2110	05 49 46.4	−07 23 02	0.007	15.2	Sy2, rad, −1–15–4
MCG 8–11–11	05 51 09.7	46 25 51	0.020	14.62	Sy1, rad, U 3374
Mrk 376	07 10 36.2	45 47 07	0.056	14.62	Sy1
Mrk 9	07 32 42.2	58 52 56	0.039	14.37	Sy1
Mrk 78	07 37 56.8	65 17 42	0.038	14.58	Sy2, radio
*Mrk 79	07 38 47.3	49 55 41	0.022	14.27	Sy1, rad, U 3973, 8–14–23
Mrk 382	07 52 03.6	39 19 07	0.034	15.50	Sy1, MCG 7–17–1
Mrk 704	09 15 39.4	16 30 59	0.029	14.28	Sy1, MCG 3–24–43
NGC 2992	09 43 17.6	−14 05 43	0.007	13.78	Sy1, rad, Arp 245
NGC 3227	10 20 46.8	20 07 08	0.003	11.79	Sy1, radio, Ho 187
Mrk 142	10 22 23.0	51 55 50	0.045	15.77	Sy1
Mrk 40	11 22 47.8	54 39 26	0.020	15.18	Sy1, I Zw 26, Arp 155
Mrk 739	11 33 52.7	21 52 22	0.030	14.08	H II G, NGC 3758
NGC 3884	11 43 38.0	20 39 46	0.029	15.6	Sy1, rad, Ho 290a
NGC 3998	11 55 20.9	55 43 55	0.004	12.1	Sy1, rad, Ho 310a
NGC 4051	12 00 36.4	44 48 35	0.002	12.92	Sy1, rad, U 7030
NGC 4151	12 08 01.0	39 41 02	0.003	11.85	Sy1, rad, Ho 345a
*Mrk 766	12 15 55.6	30 05 26	0.012	14.00	Sy1, rad, N 4253, Ton N76
Mrk 205	12 19 31.8	75 35 18	0.070	15.24	Sy1, rad, in NGC 4319
NGC 4388	12 23 15.0	12 56 18	0.008	13.90	Sy2, radio
Mrk 1330	12 37 04.6	−05 04 11	0.009	13.15	Sy1, rad, NGC 4593
NGC 5033	13 11 09.2	36 51 30	0.003	12.03	Sy1, rad, U 8307, 6–29–51
Mrk 279	13 51 53.6	69 33 13	0.031	14.58	Sy1, radio, MCG 12–13–25
NGC 5506	14 10 39.1	−02 58 27	0.007	14.38	Sy2, radio, MCG 0–36–28
*NGC 5548	14 15 43.5	25 22 01	0.017	13.73	Sy1, radio, MCG 4–34–13
Mrk 474	14 33 06.1	48 52 47	0.041	15.25	Sy1, NGC 5863
E 1530–085	15 30 37.0	−08 31 22	0.023	15.7	Sy2, MCG–1–40–1, Ho 711a
1E 15335 + 146	15 33 32.8	14 40 57	0.020	14.7	Sy2, MCG 3–4–9
Mrk 290	15 34 44.8	58 04 00	0.029	14.96	Sy1
Mrk 291	15 52 54.1	19 20 16	0.035	15.72	Sy1
Mrk 876	16 13 36.2	65 50 37	0.129	15.23	Sy1
H 1613 + 06	16 15 18.2	06 11 12	0.038	15.66	Sy1
Mrk 877	16 17 56.5	17 31 35	0.114	15.46	Sy1
U 10683 b	17 02 24.7	−01 28 23	0.031	15.55	Sy1
Arp 102 b	17 17 56.3	49 01 58	0.025	14.7	Sy1, radio

Table I (continued)

Object	α_{1950}	δ_{1950}	z	V	Remarks
*Mrk 506	17ʰ20ᵐ45.6	30°55′40″	0.043	14.68	Sy1, Kar 510a
E 1739+518	17 39 16.0	51 51 19	0.061	15.2	Sy1
Mrk 507	17 48 55.3	68 42 50	0.053	15.45	Sy2
Kaz 102	18 03 37.4	67 37 54	0.136	15.76	Sy1
3C 382.0	18 33 12.0	32 39 18	0.059	15.39	Sy1, radio
3C 390.3	18 45 37.6	79 43 06	0.057	15.38	Sy1, radio
NGC 6814	19 39 55.7	−10 26 34	0.005	14.21	Sy1, rad, MCG −2–5–1
*Mrk 509	20 41 26.2	−10 54 17	0.035	13	Sy1, radio
*Mrk 304	22 14 45.8	13 59 20	0.067	14.66	Sy1, II Zw 175
3C 445.0	22 21 14.8	−02 21 26	0.057	15.77	Sy1, radio
*NGC 7469	23 00 44.4	08 36 16	0.017	13.04	Sy1, radio
Mrk 315	23 01 35.7	22 21 16	0.040	14.78	Sy1, radio, II Zw 187
Mrk 926	23 02 07.2	−08 57 20	0.047	14.18	Sy1, radio
Mrk 541	23 53 28.4	07 14 41	0.040	15.15	Sy1

centre of the black hole; V_k, the Keplerian velocity for a given R; and R_g, the gravitational radius, is about 1 day. In consequence, we should observe a certain variability of 1 day time-scale.

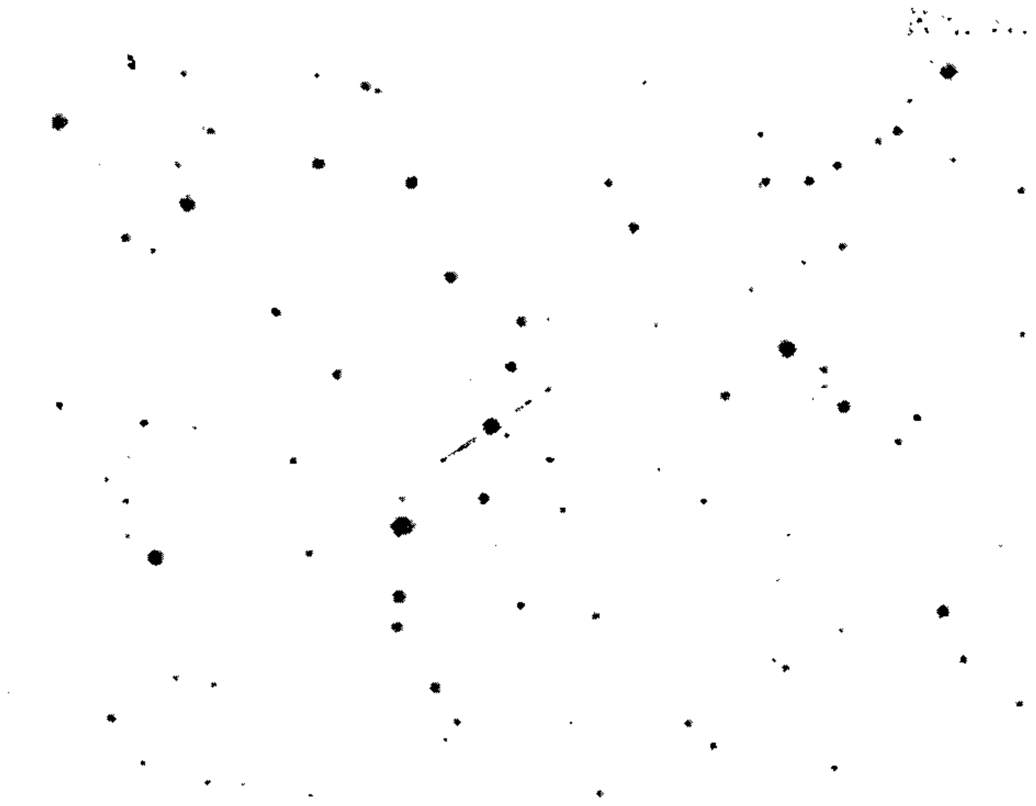
(3) As it is well known, higher velocities are observed closer to the central source. Shuder (1982) indicated that the smaller the distance from the centre, the higher the velocity of Balmer and He I profiles of the lines. On the other hand, if the broad lines of low-ionization atoms are spectrally shifted in respect to those highly ionized, this is an indication of radial motion of the emitted gas (Gaskell, 1982). These facts are in good agreement with another couple of models, as well – the disk accretion model, and the one of gas clouds, revolving on strongly elongated orbits (see Kwan and Carrol, 1982). Additional indications, for example V_k is about 15000 km s^{-1} at $T_{\rm eff}$ about 10^4 K, help us to choose the first one.

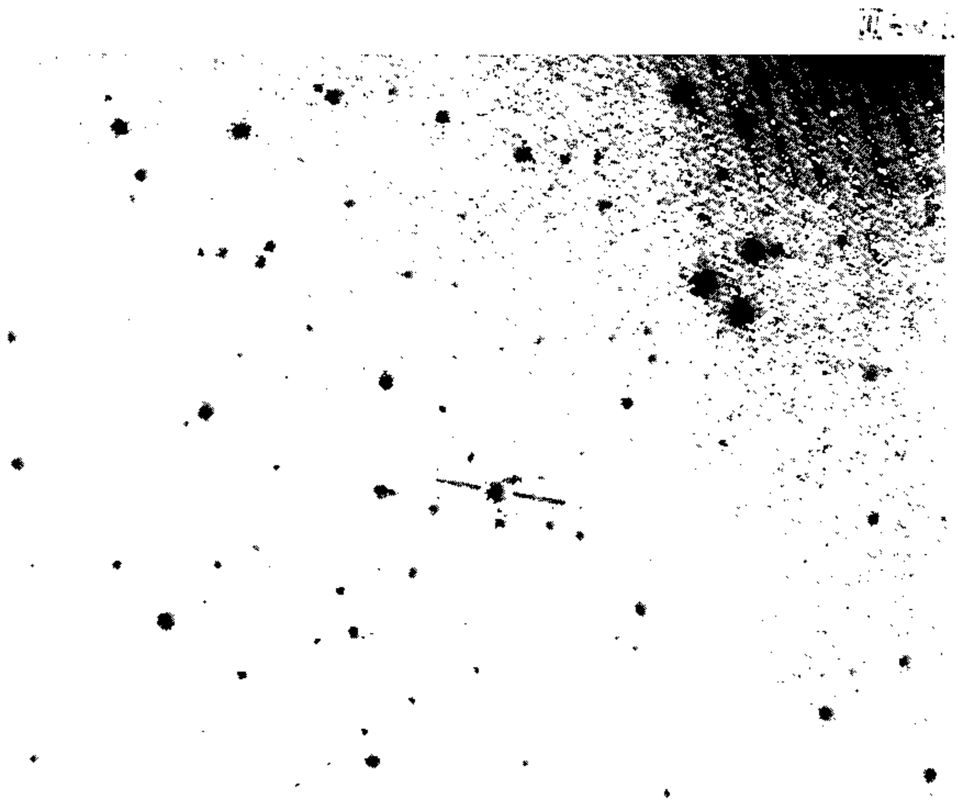
(4) Gaskell (1984) studied the possibility for a binary supermassive black hole to exist in active nuclei. In such cases, analogically to binary stars, known as X-ray sources, the central peak of broad emission lines will be shifted in respect to the Z-system, defined by the narrow lines. A number of objects of asymmetric profiles of the broad lines have been observed, and this is suggestive of such a possibility. Peterson *et al.* (1987) find a double broad-line region in NGC 5548.

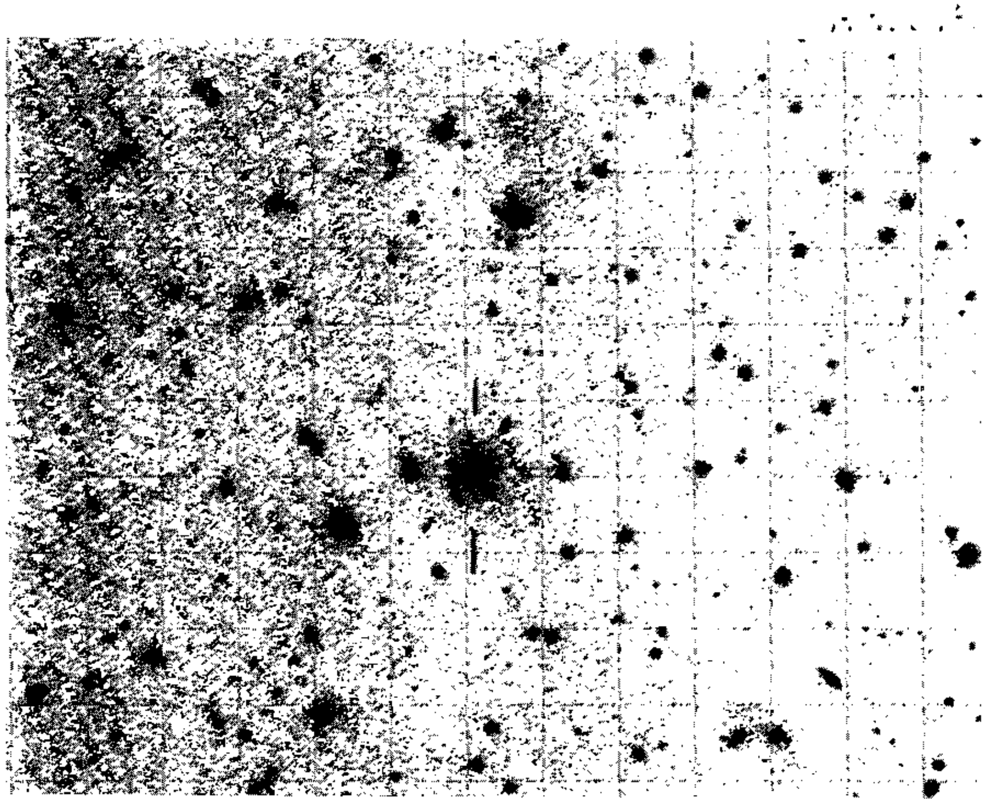
(5) Tennant and Mushotzky (1983) have shown that X-ray variability is in good agreement with the model, where the disk's atmosphere is heated to larger radii. Pounds *et al.* (1986) found strong X-ray variability on a time-scale of 1–2 hours for Mrk 335. As a result of Compton's heating, a crown of $T \sim 10^8$ K is formed at distances, where $V_k \geq 10^{3.5}$ km s^{-1}, and thermal gas pressure-induced wind (Begelman *et al.*, 1983). The heated gas may be optically thick in respect to electron collisions, in which case polarization will be observed.

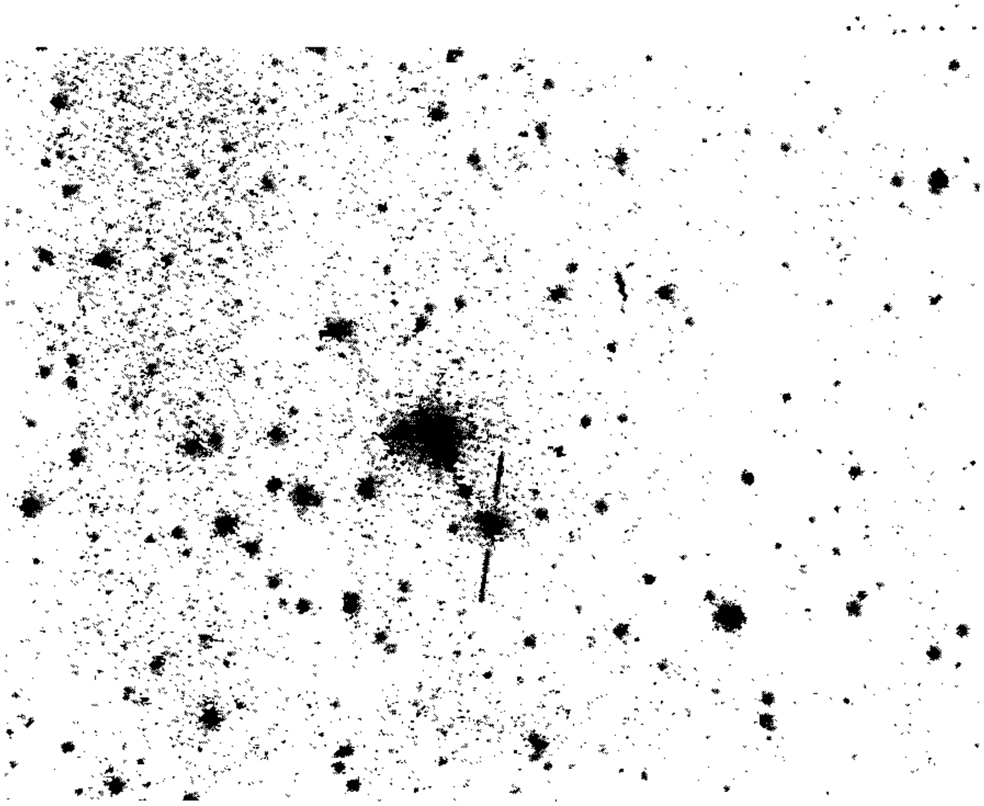
(6) Begelman (1985) showed that when the energy source is a massive black hole, the density of the emitting gas will decrease along the radius in conformity with R^{-2}.

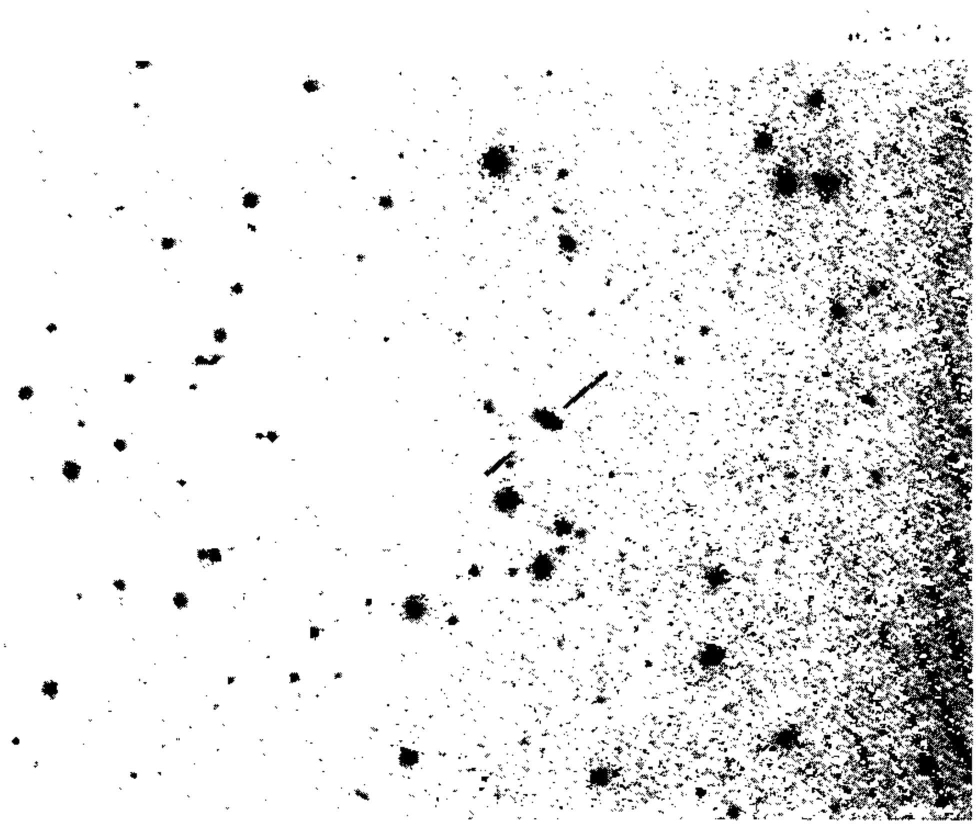
Peterson and Ferland (1986) find an accretion event in the Seyfert galaxy NGC 5548.

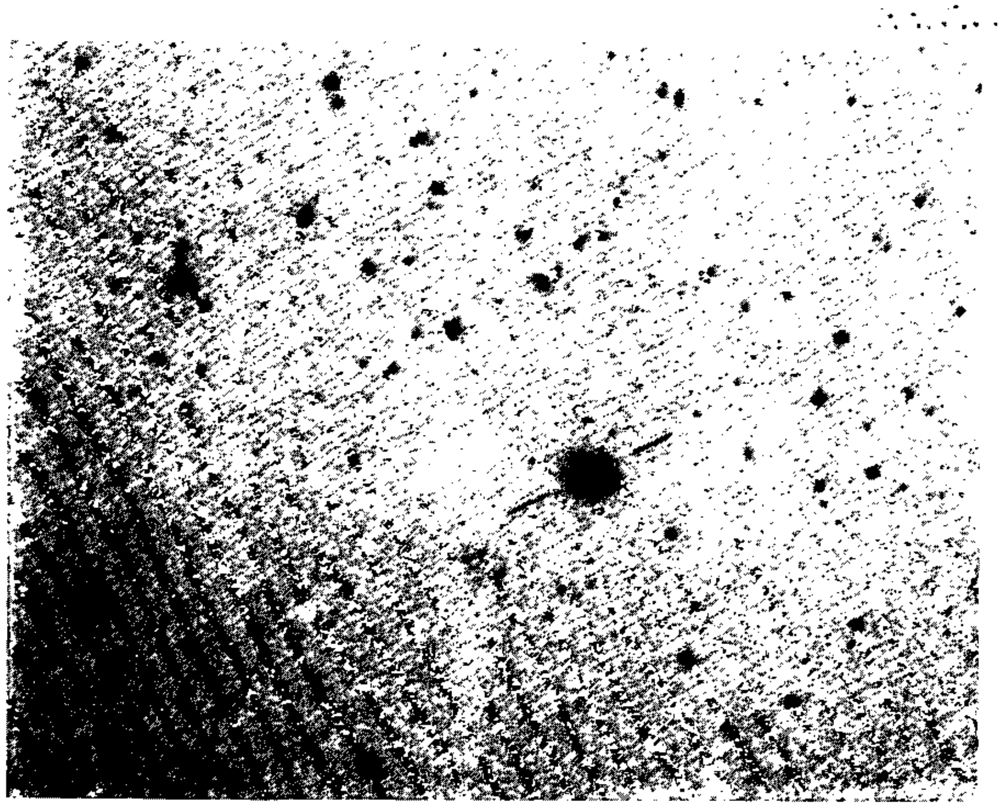


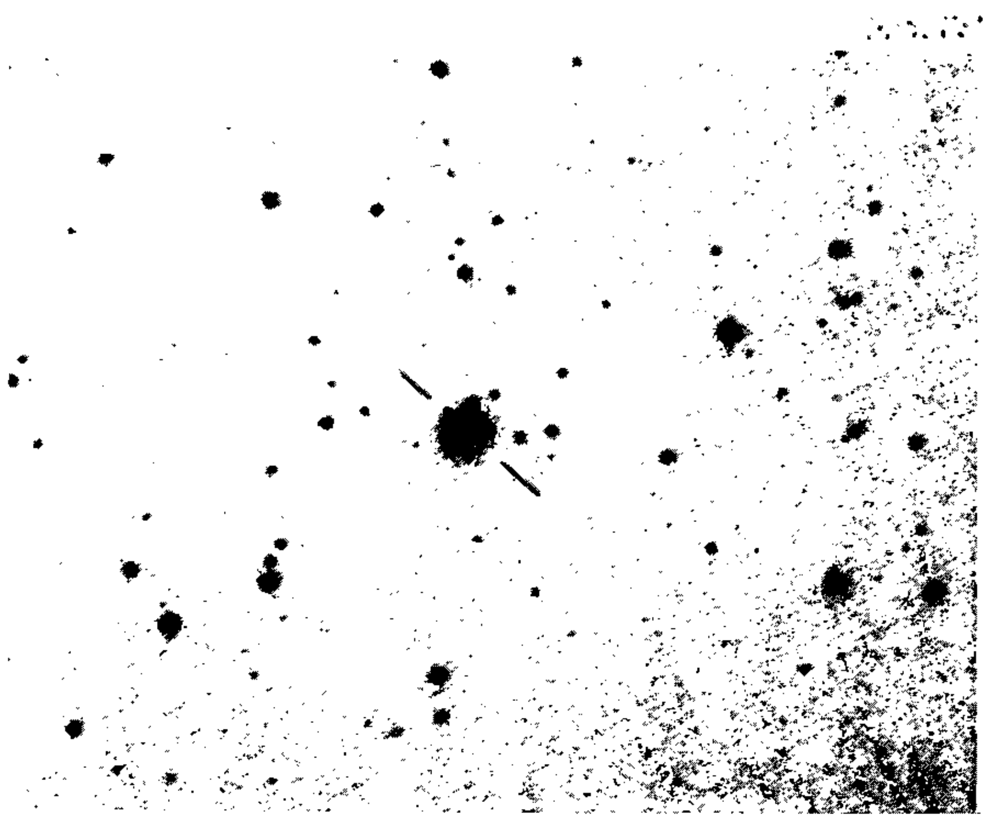


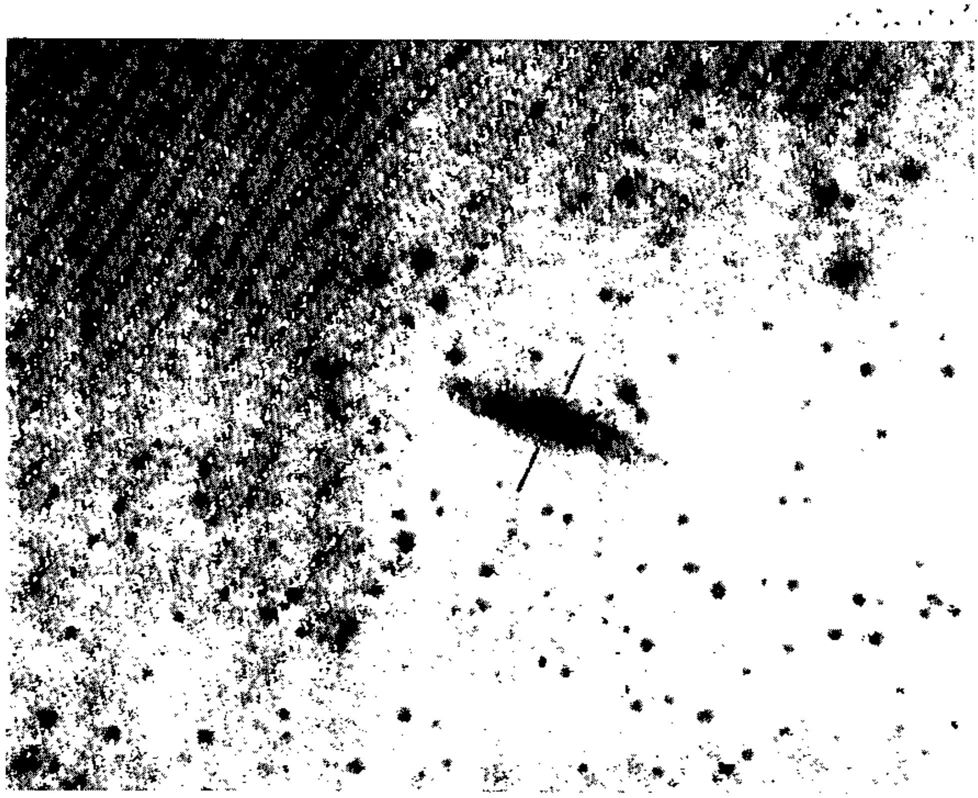


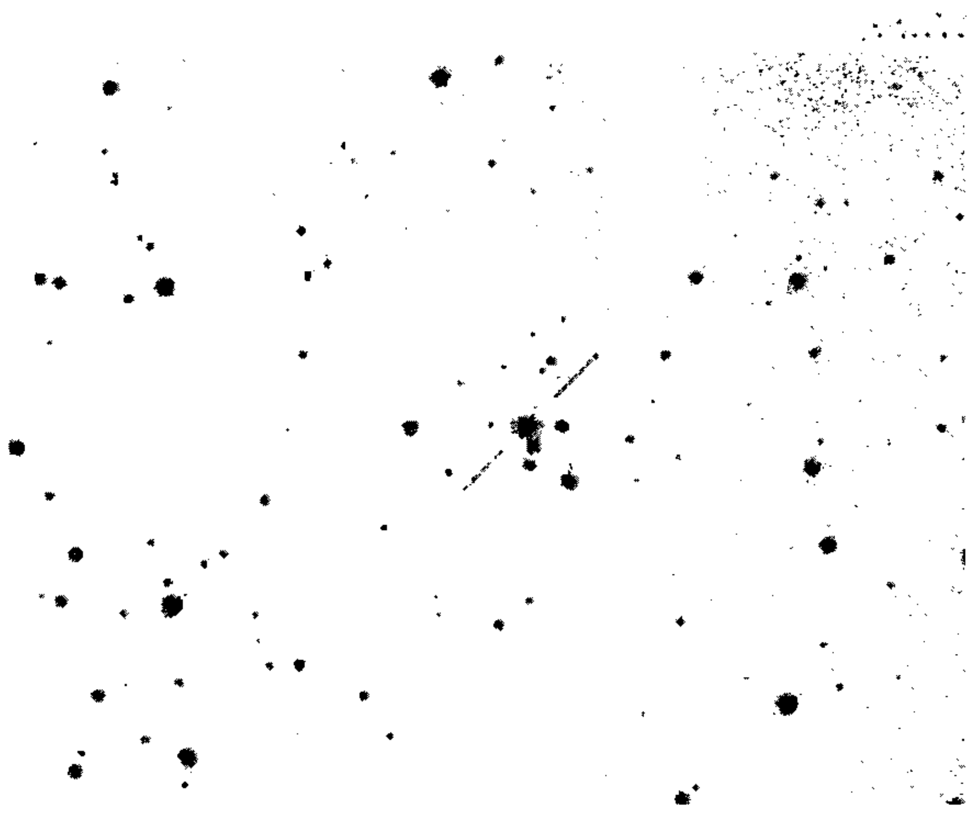


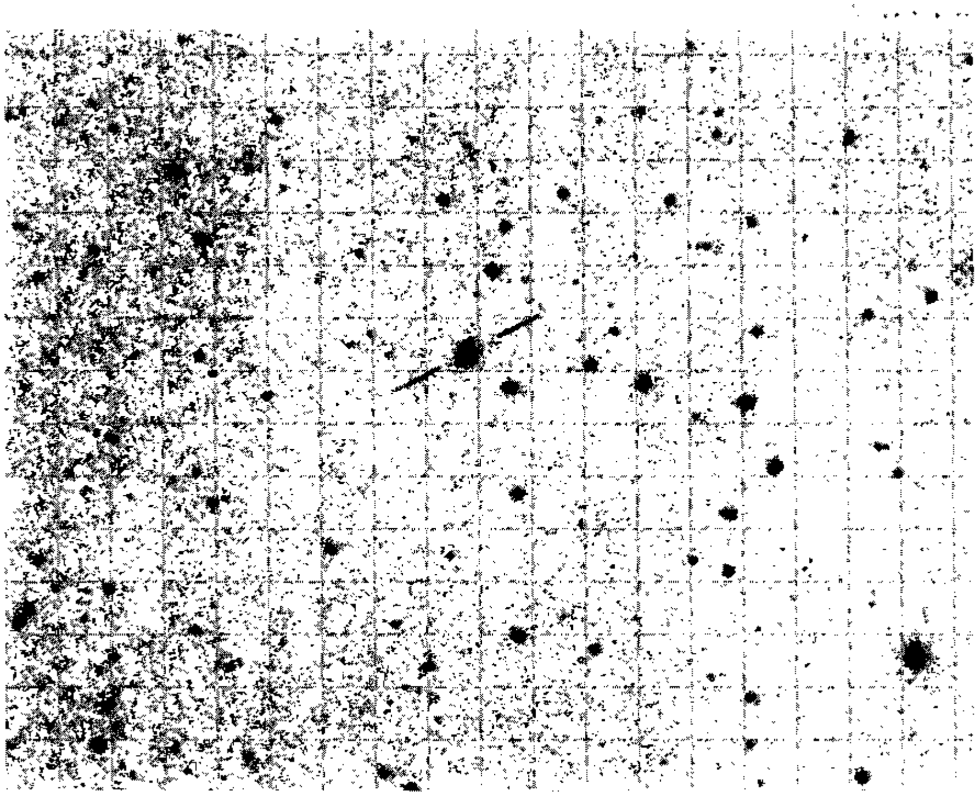


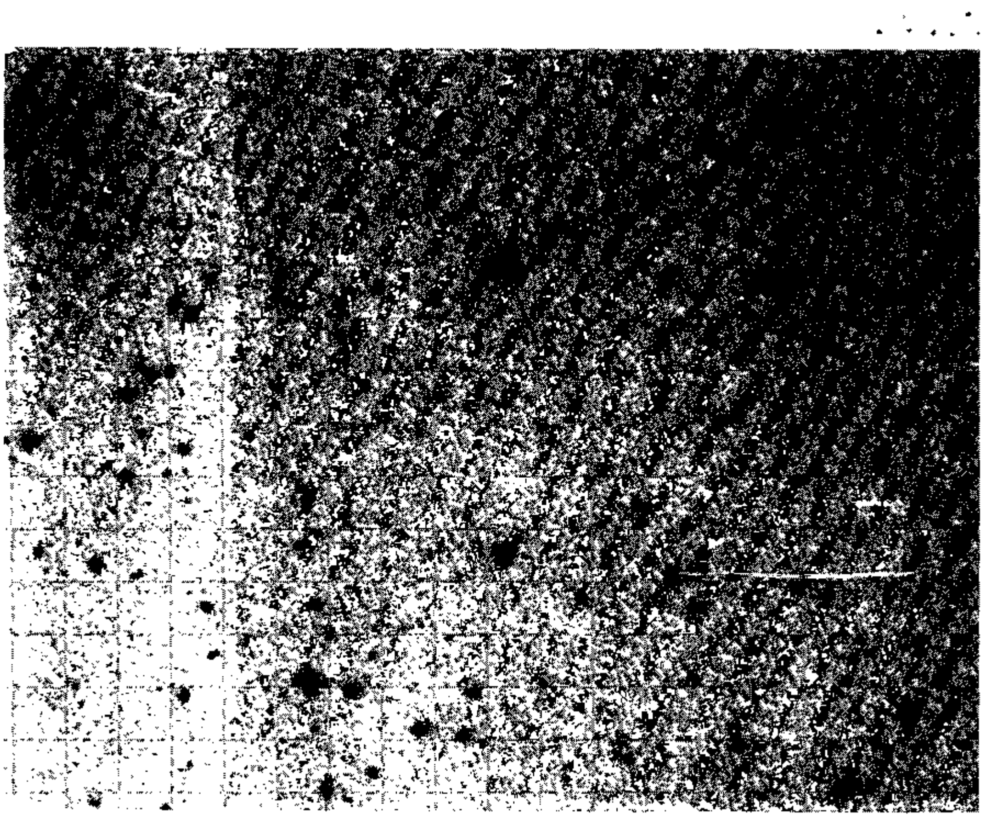


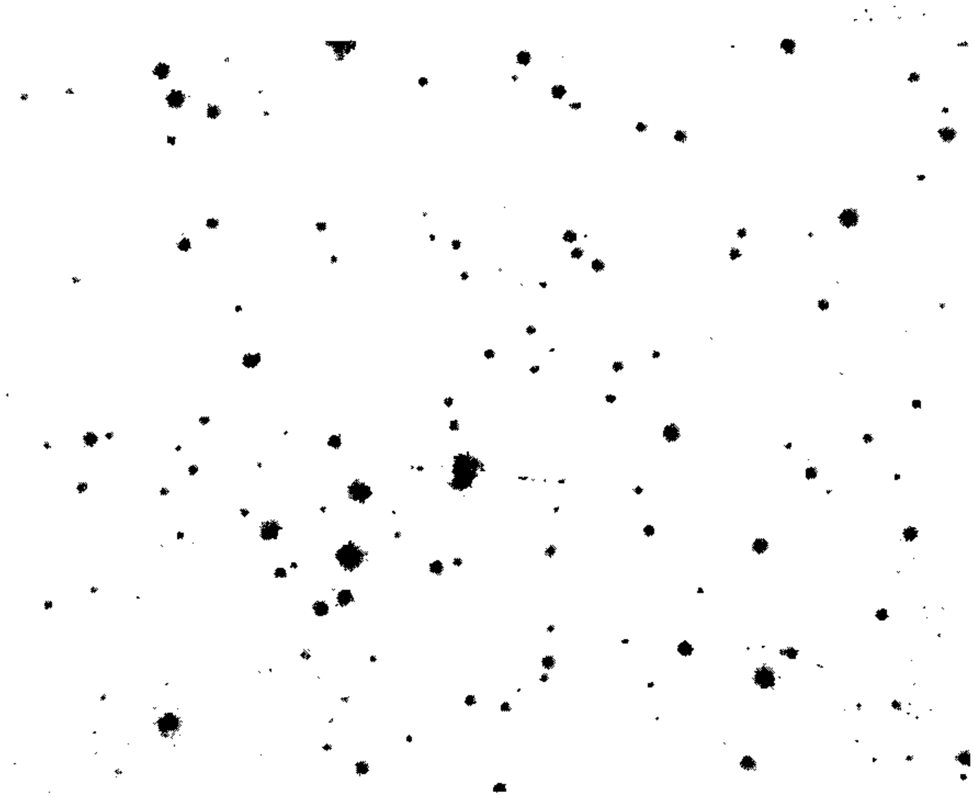


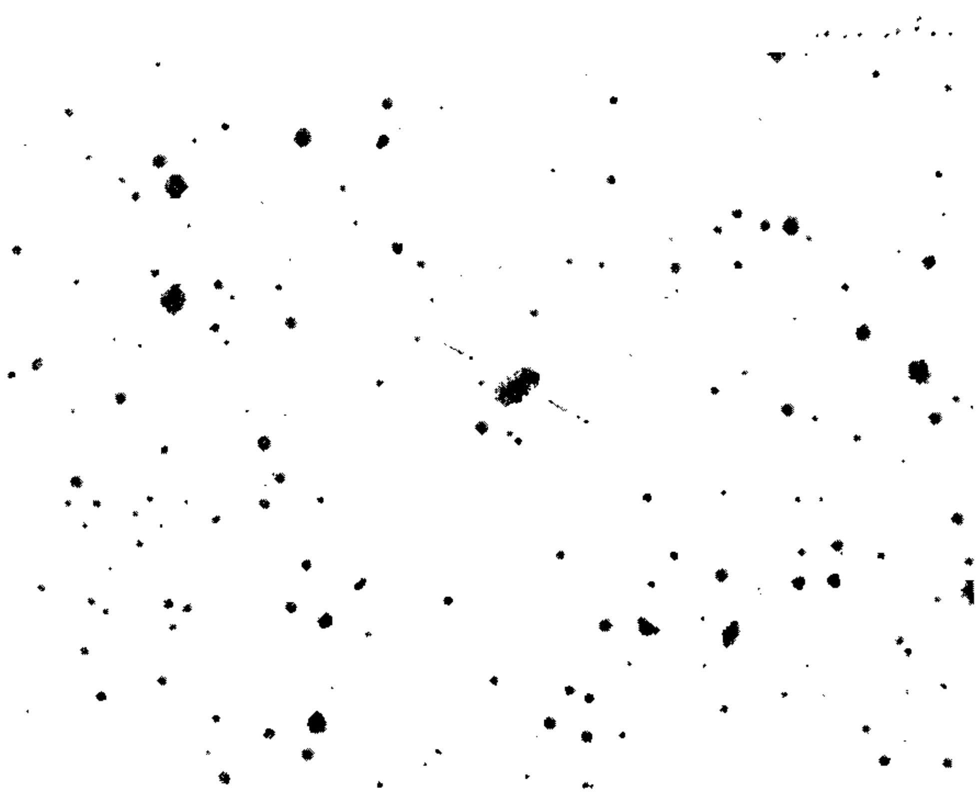


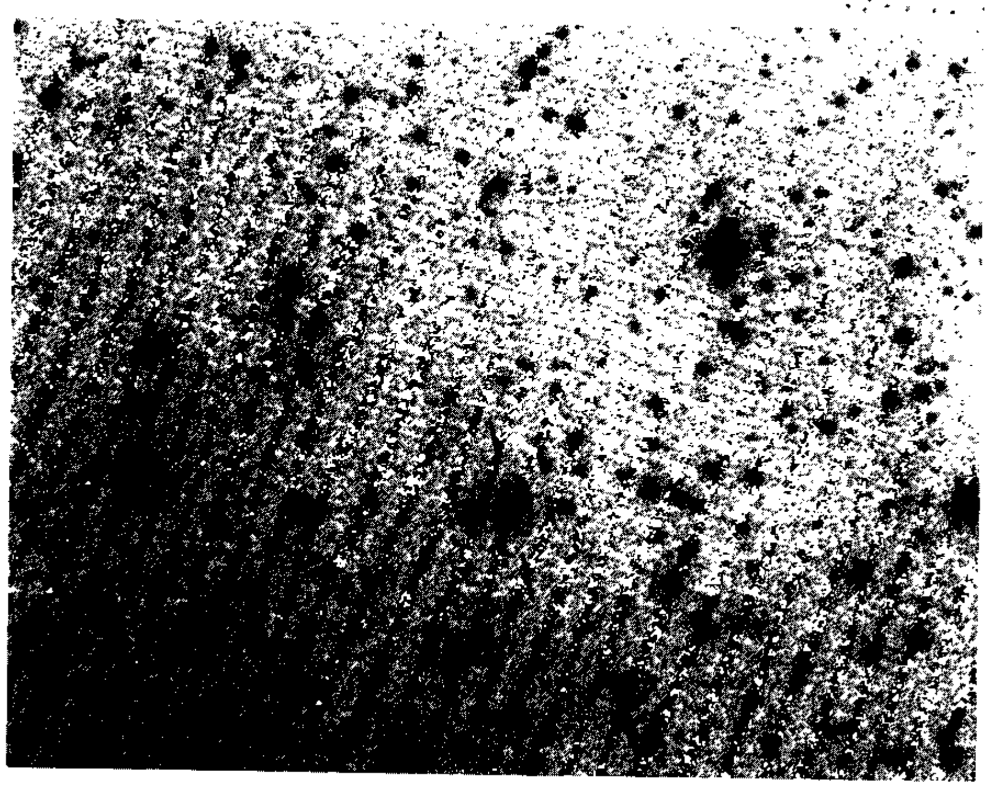


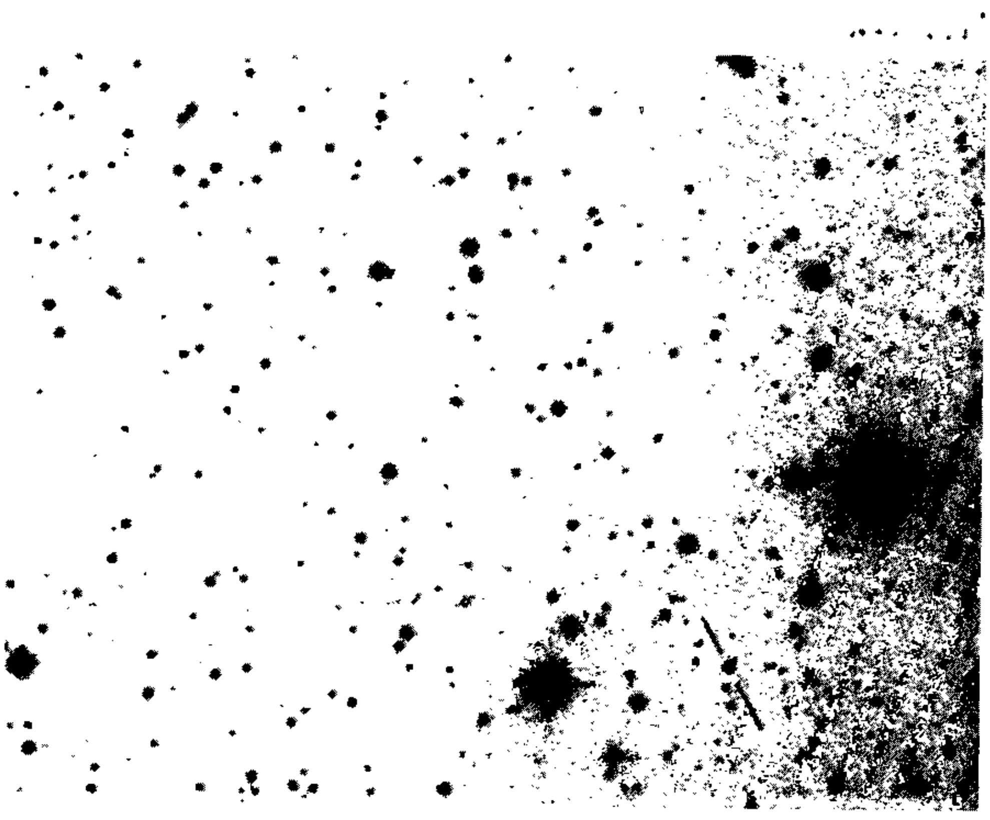


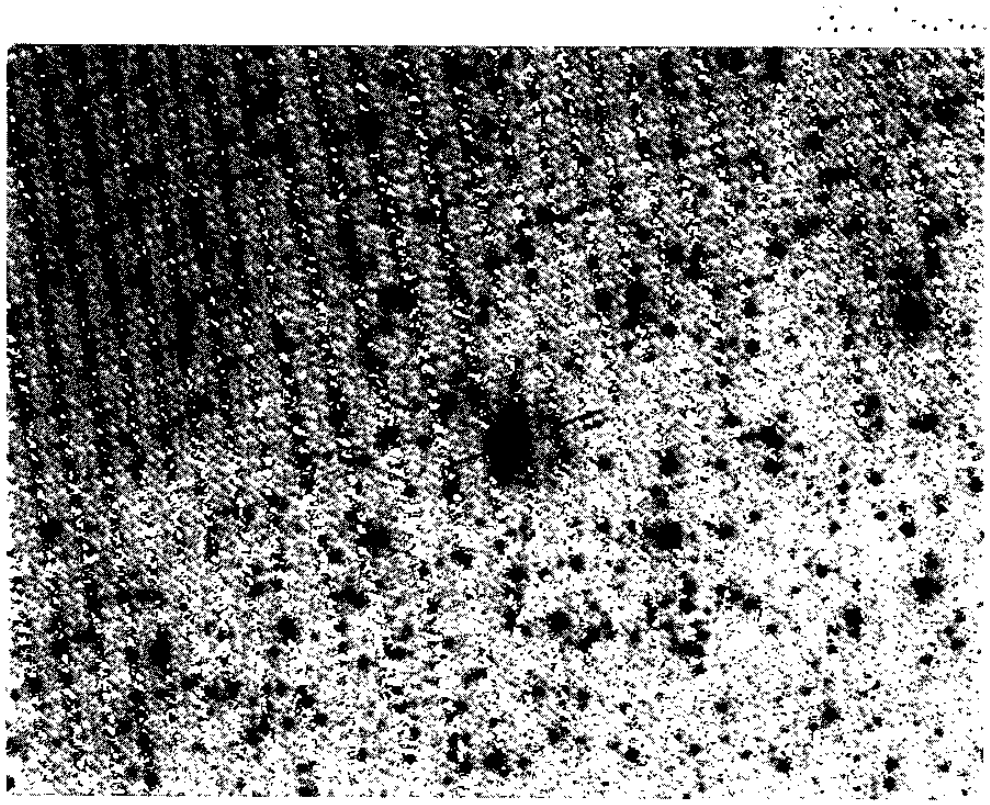


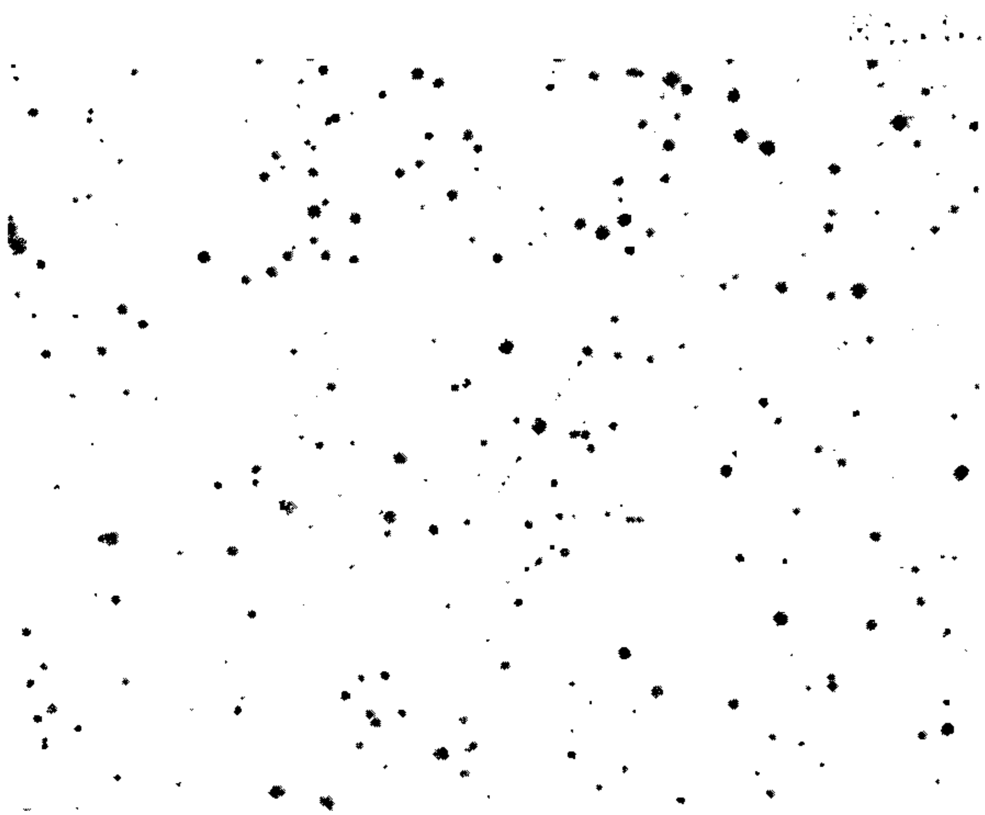


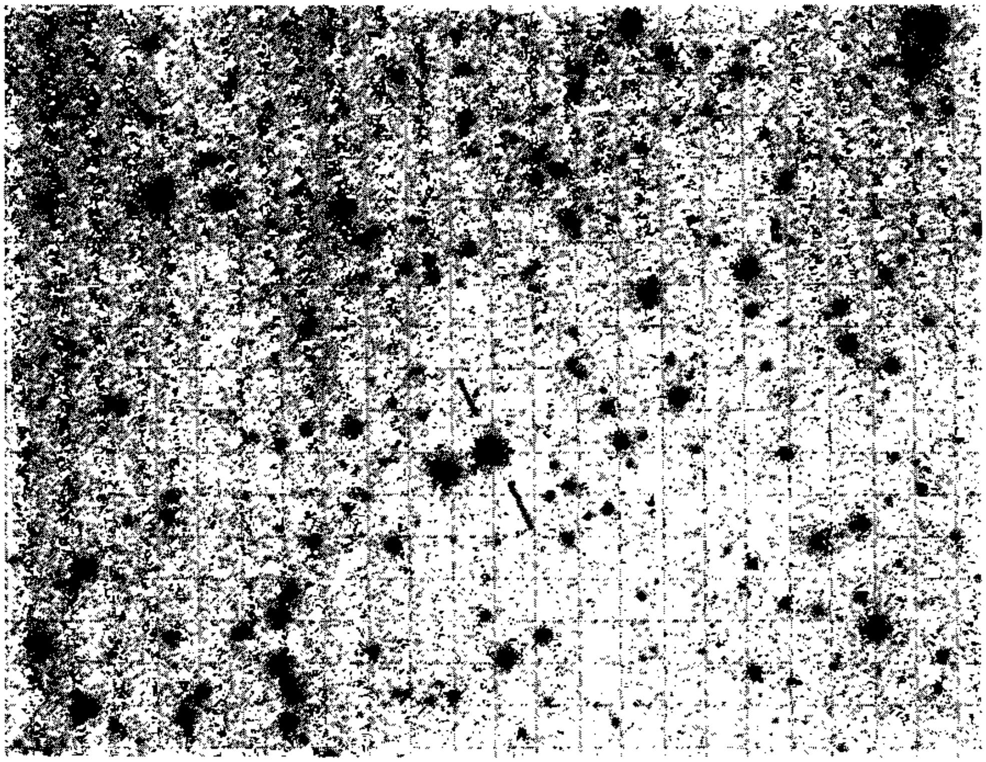


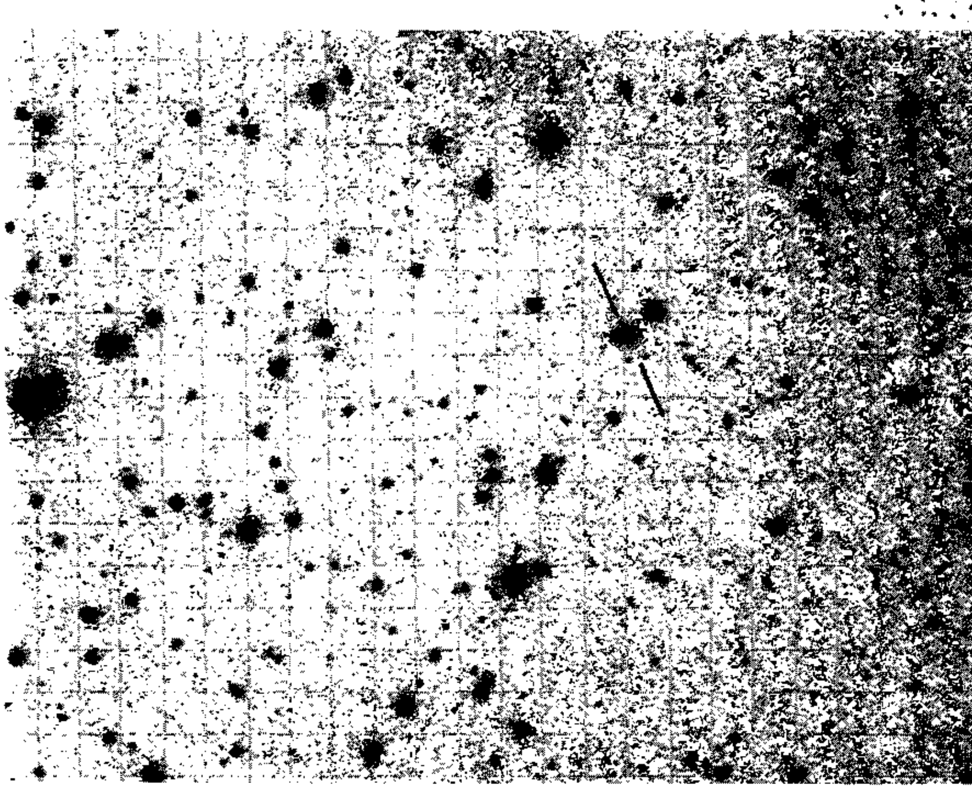


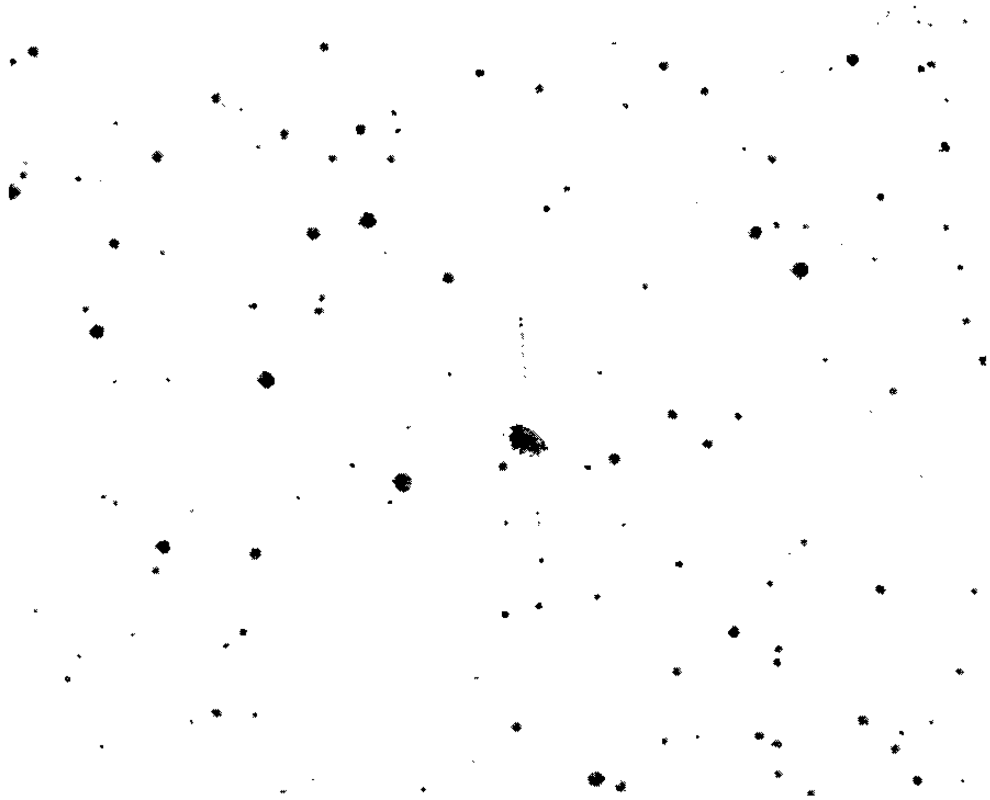


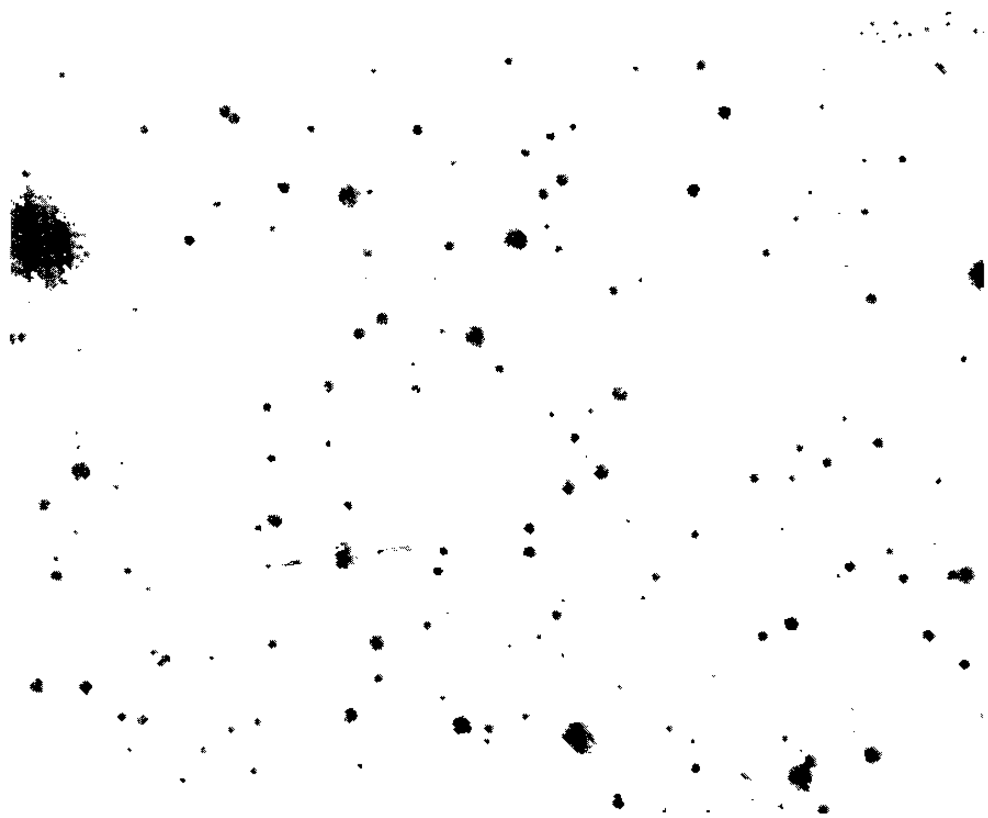


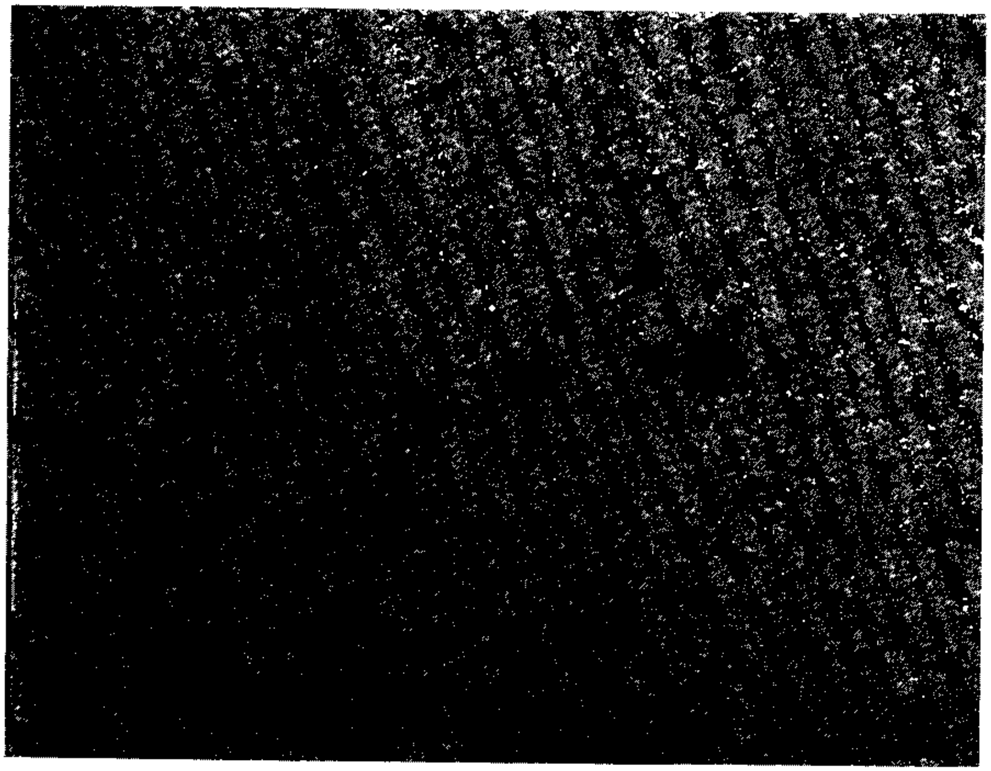


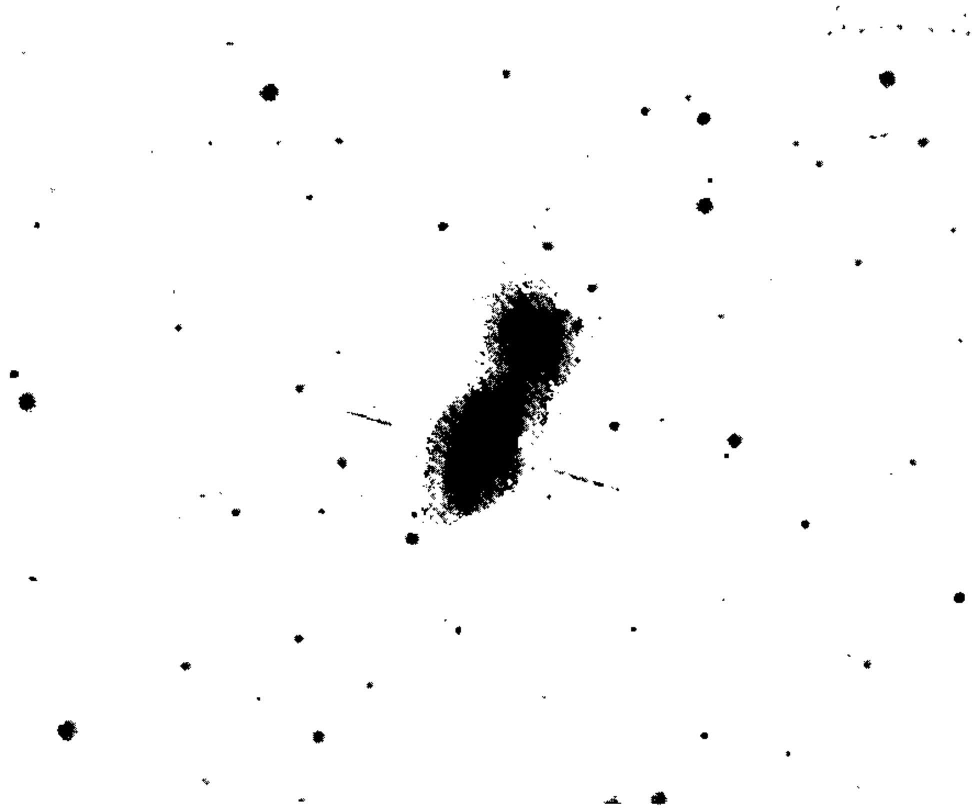


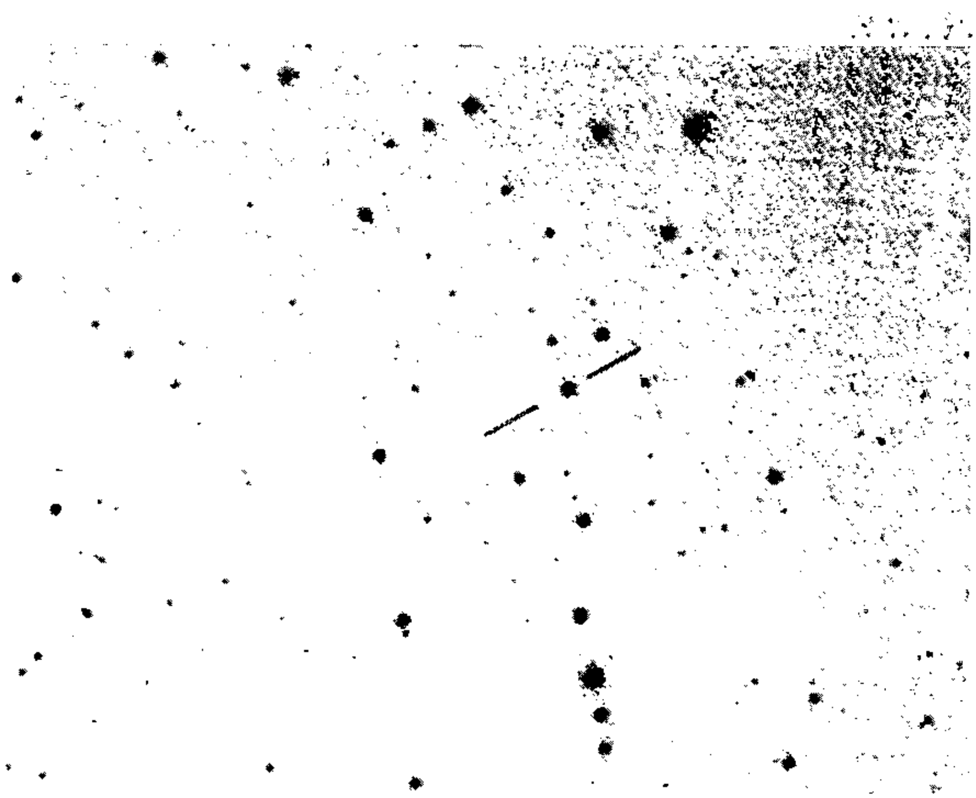


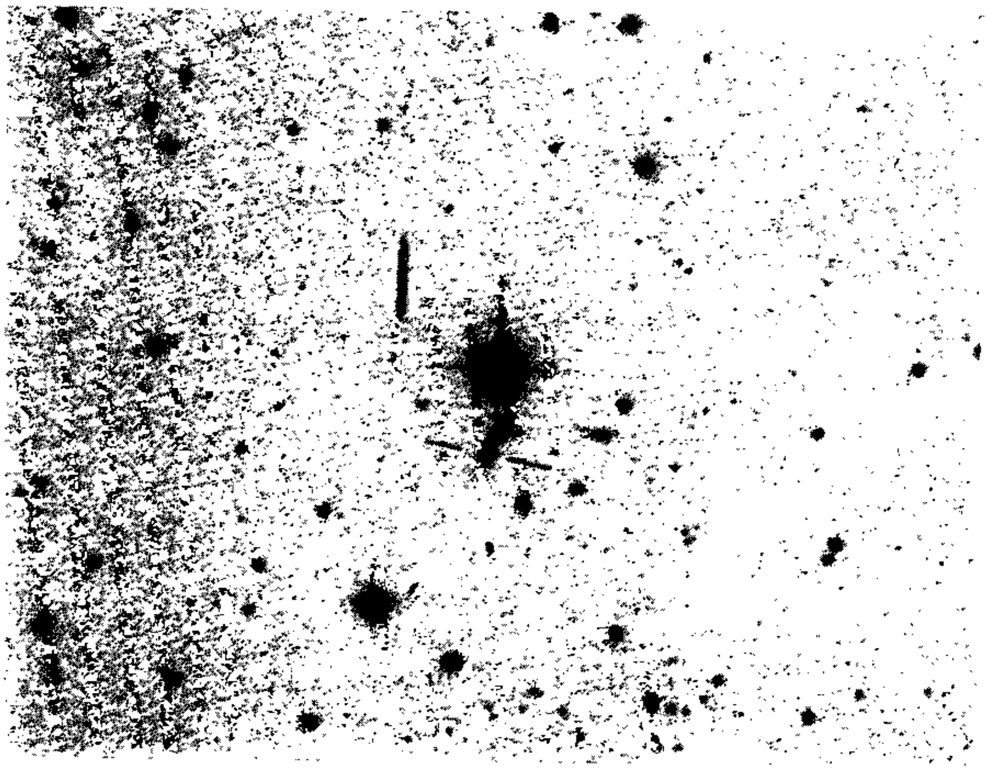


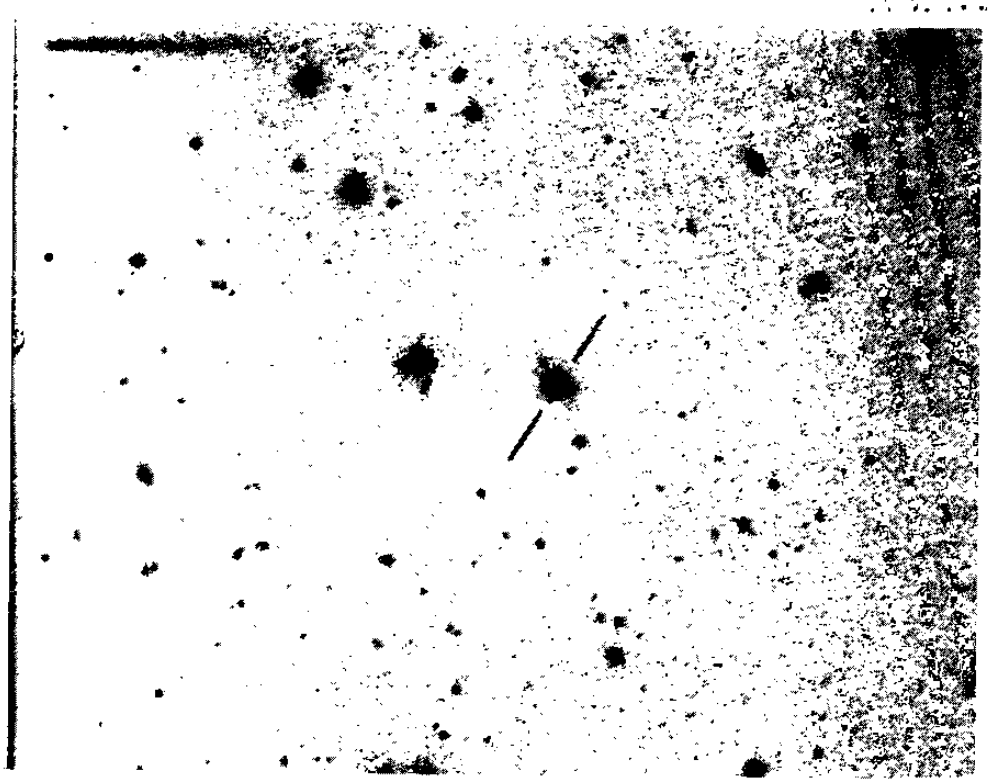


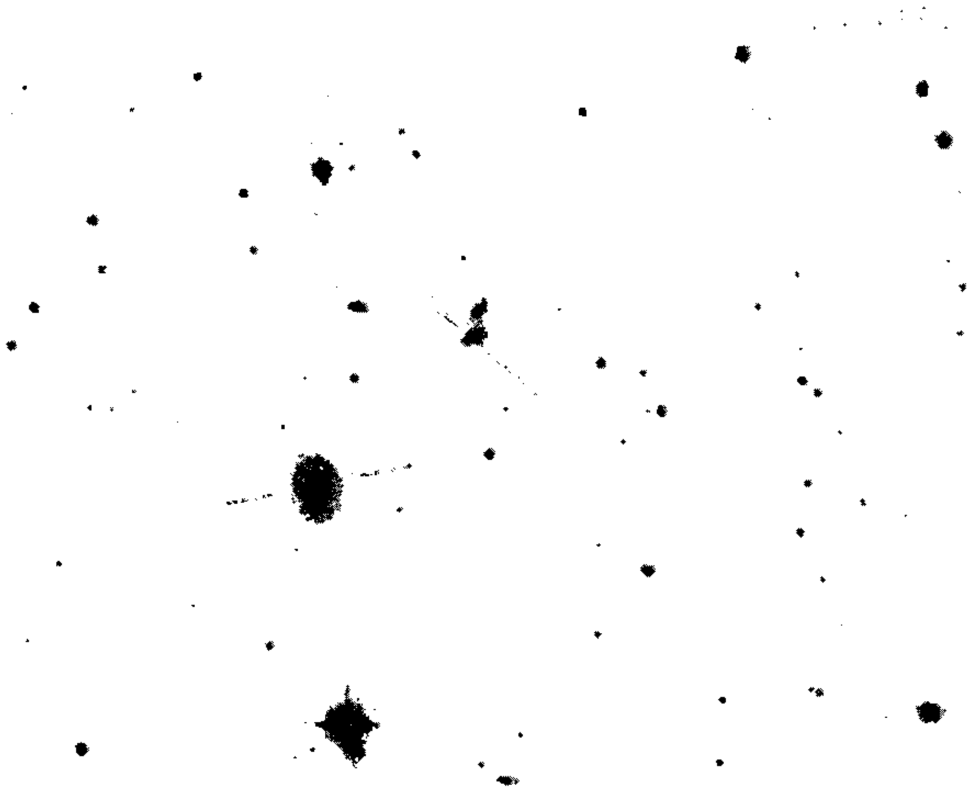


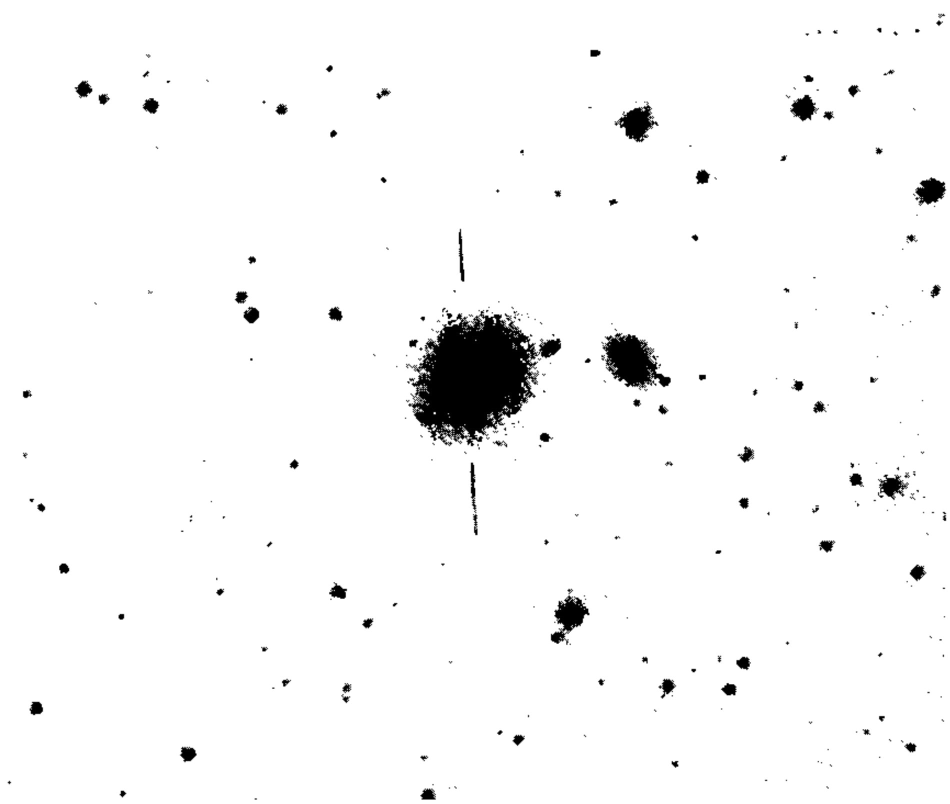


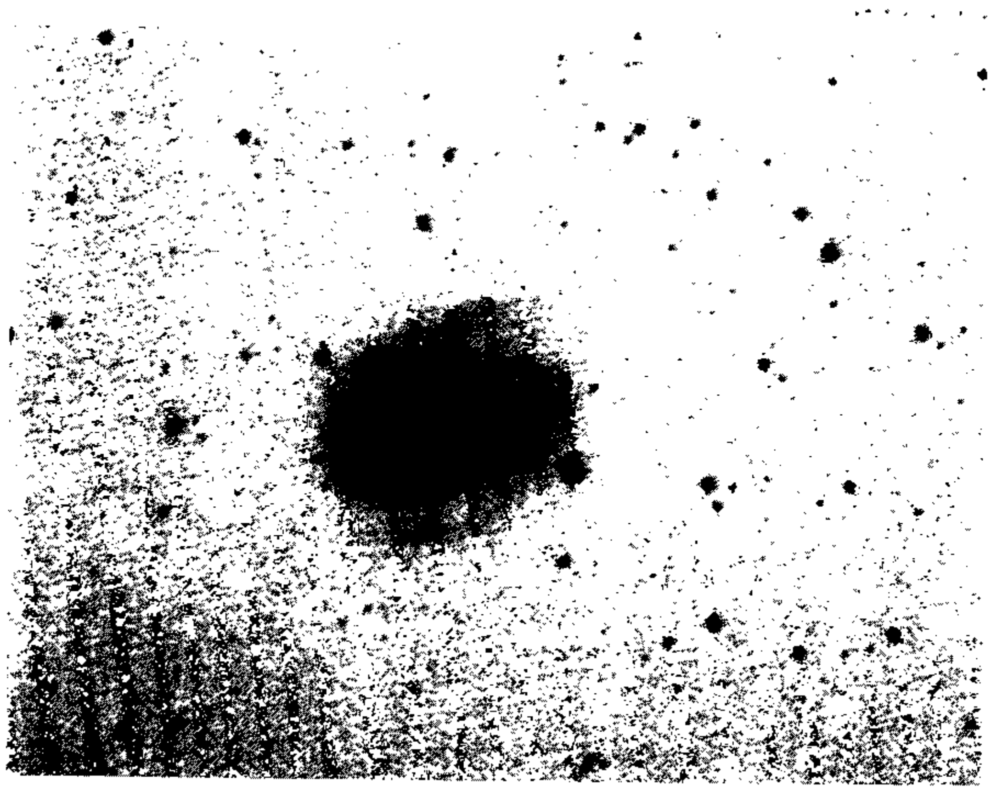


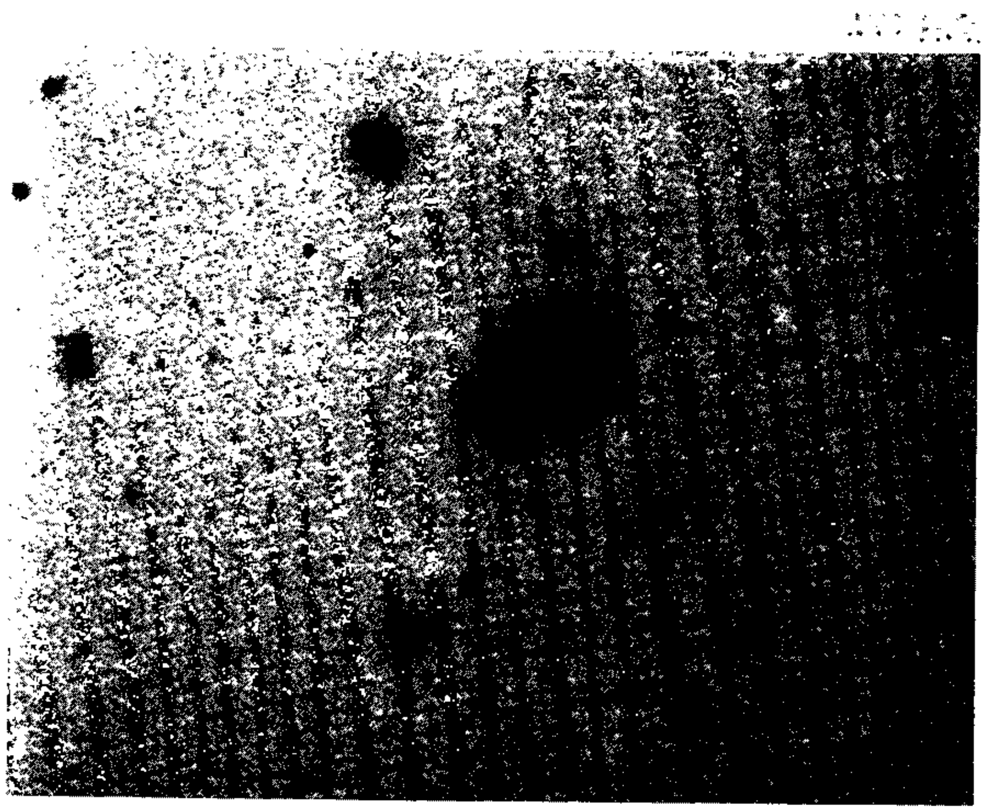


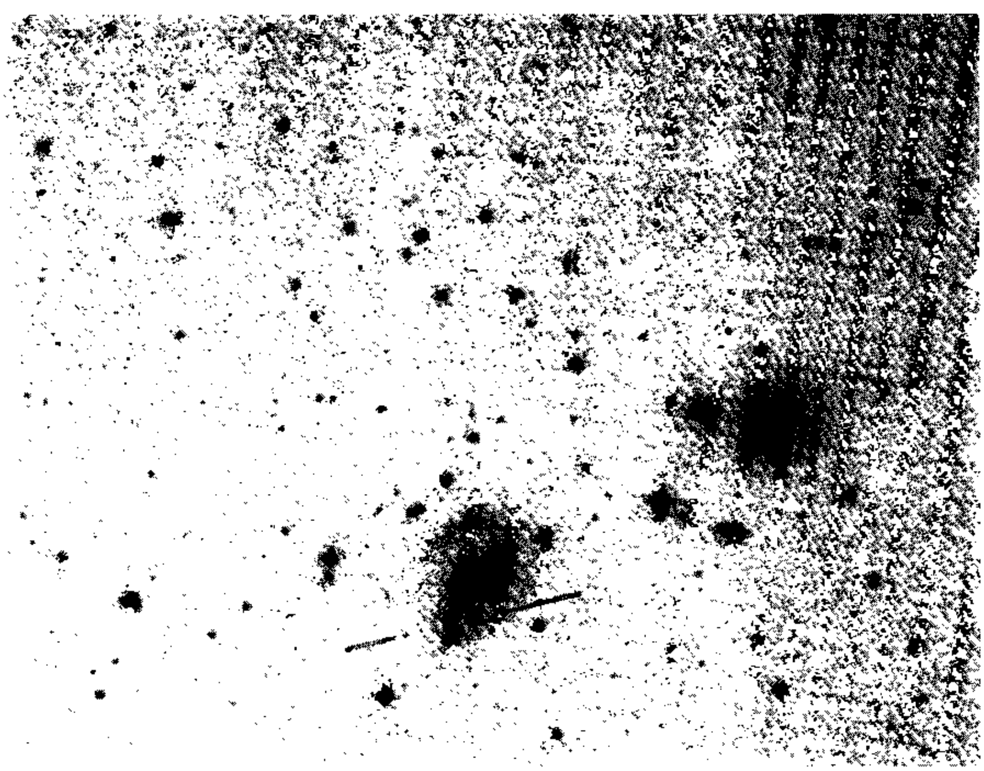


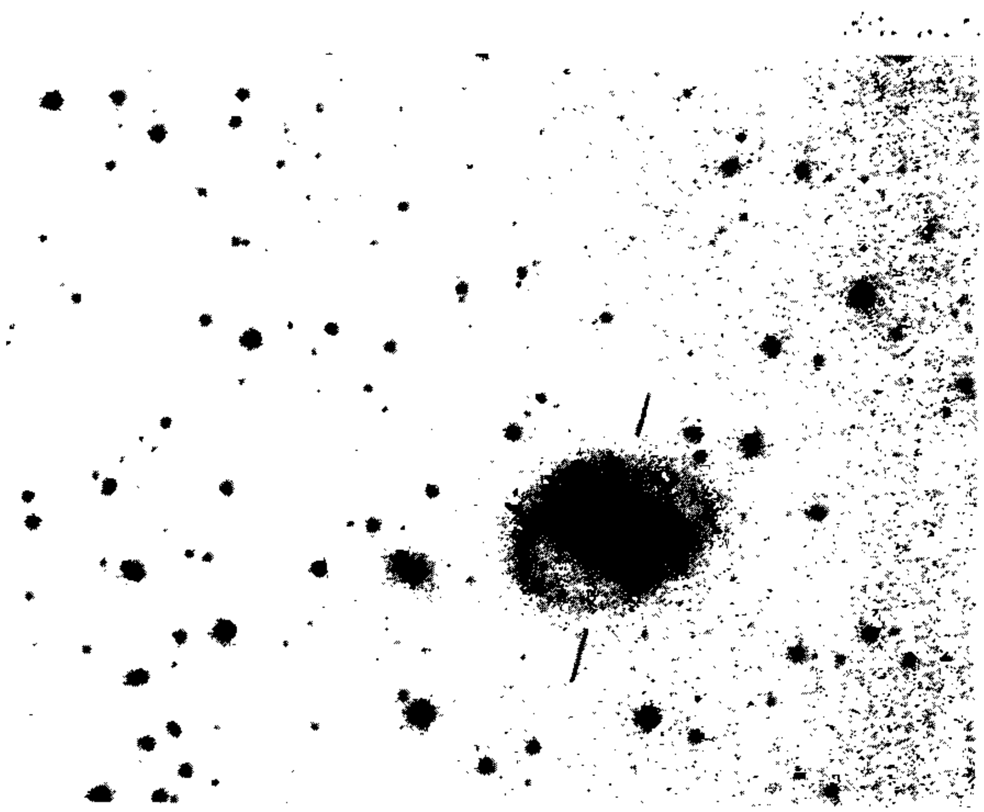


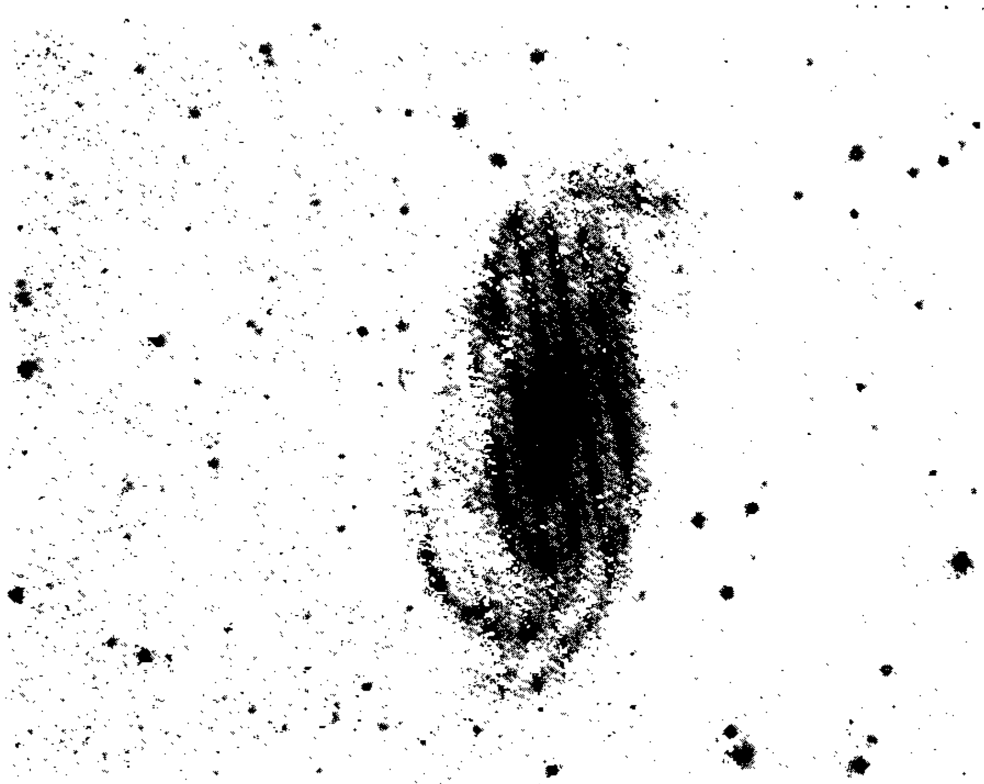


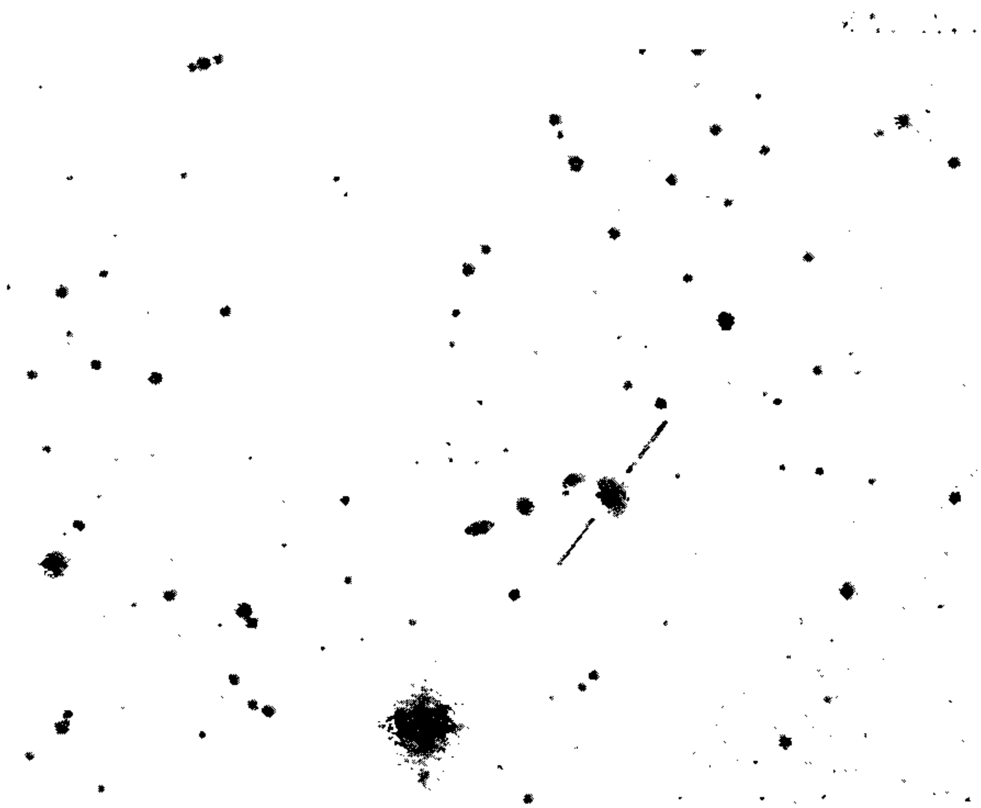


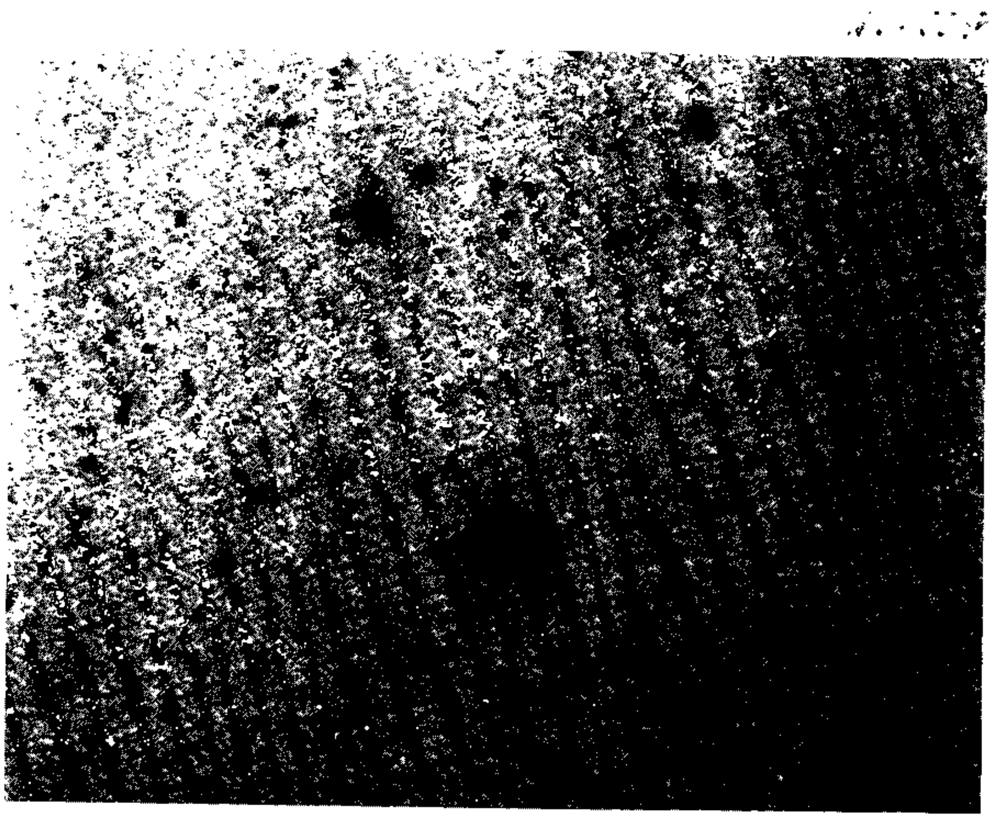


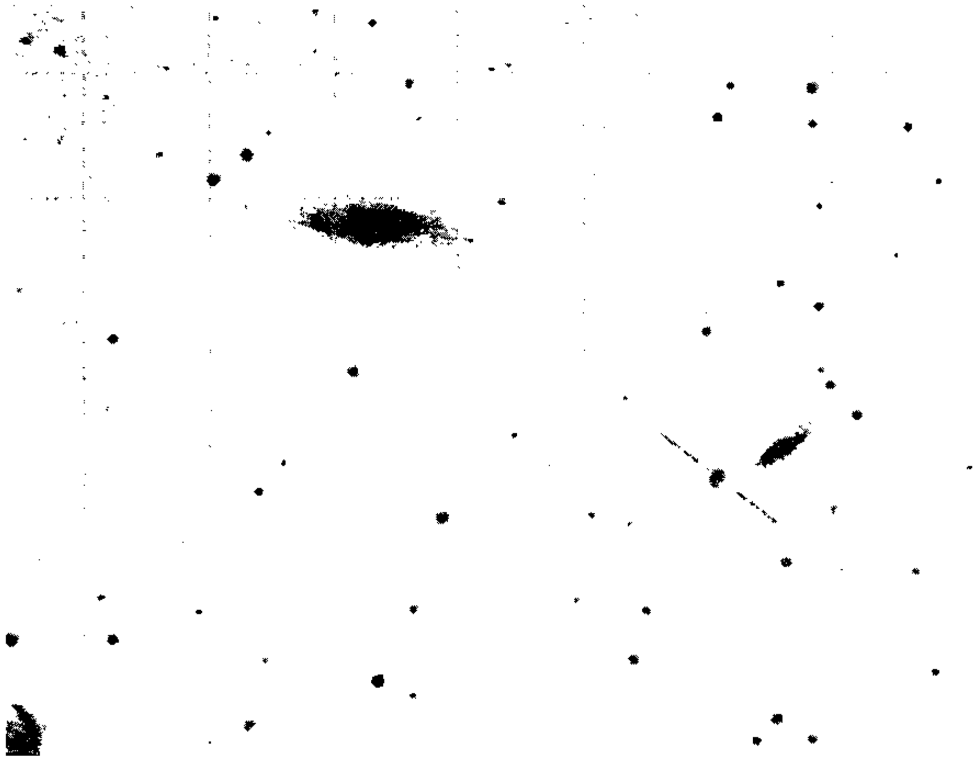


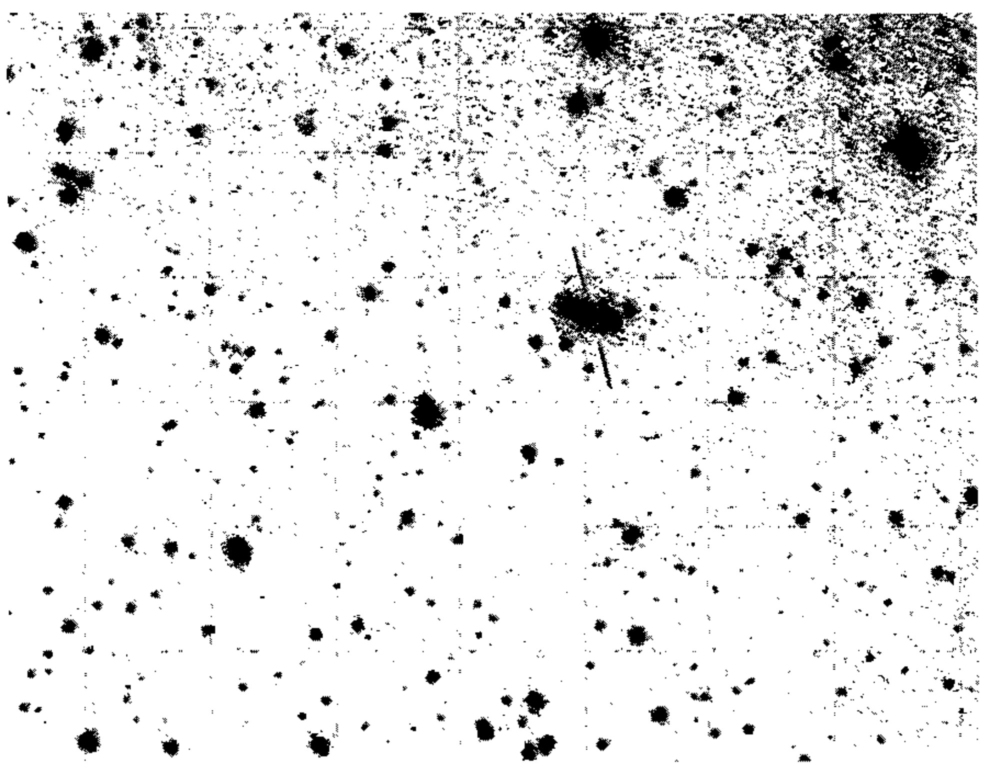


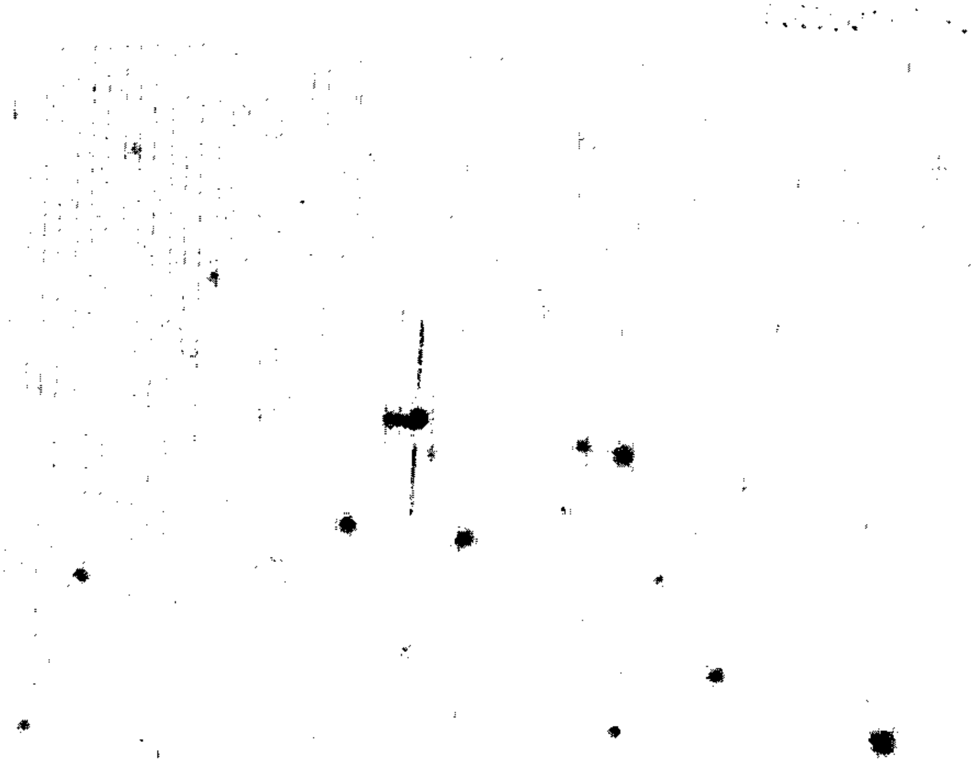


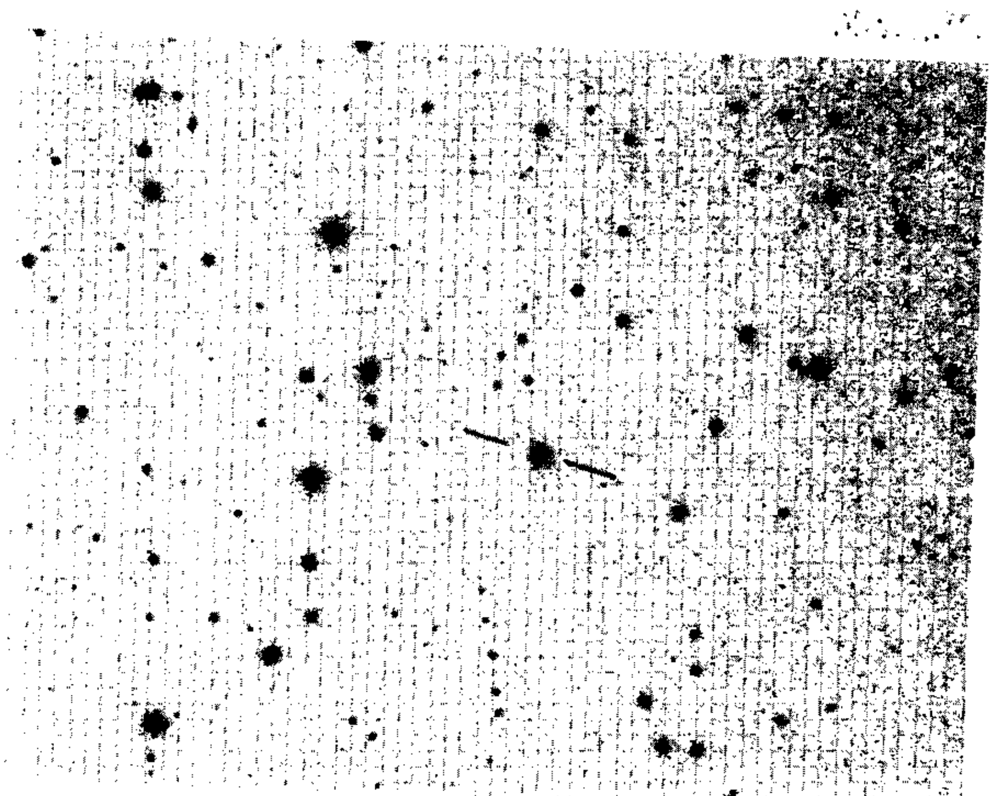


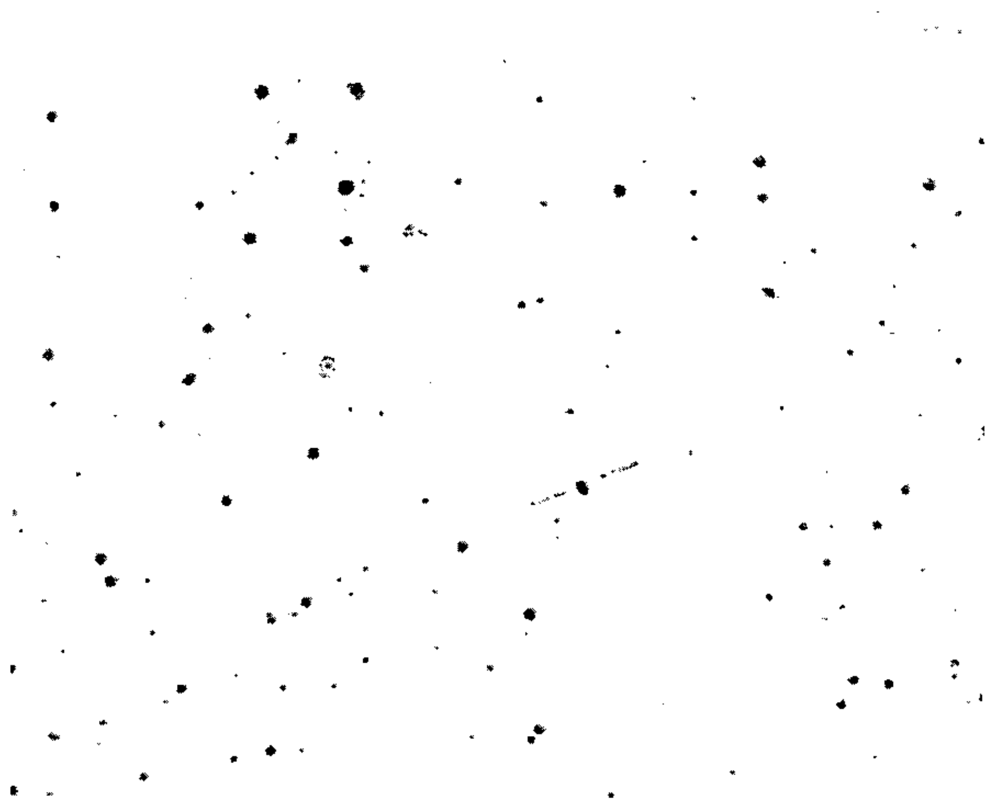


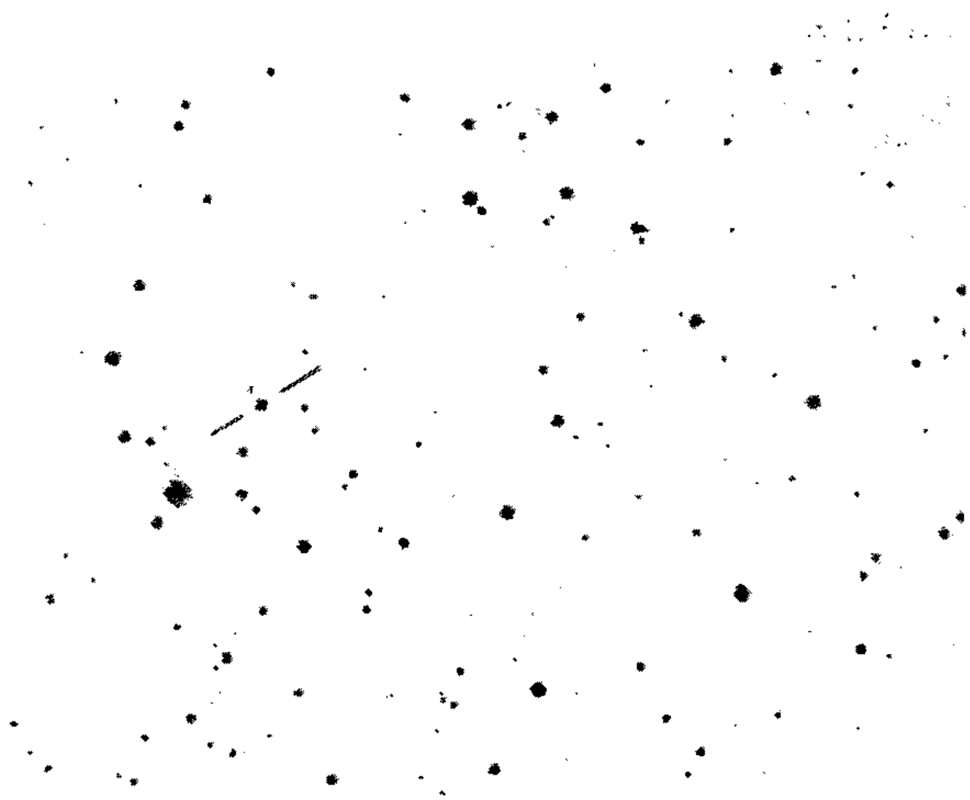












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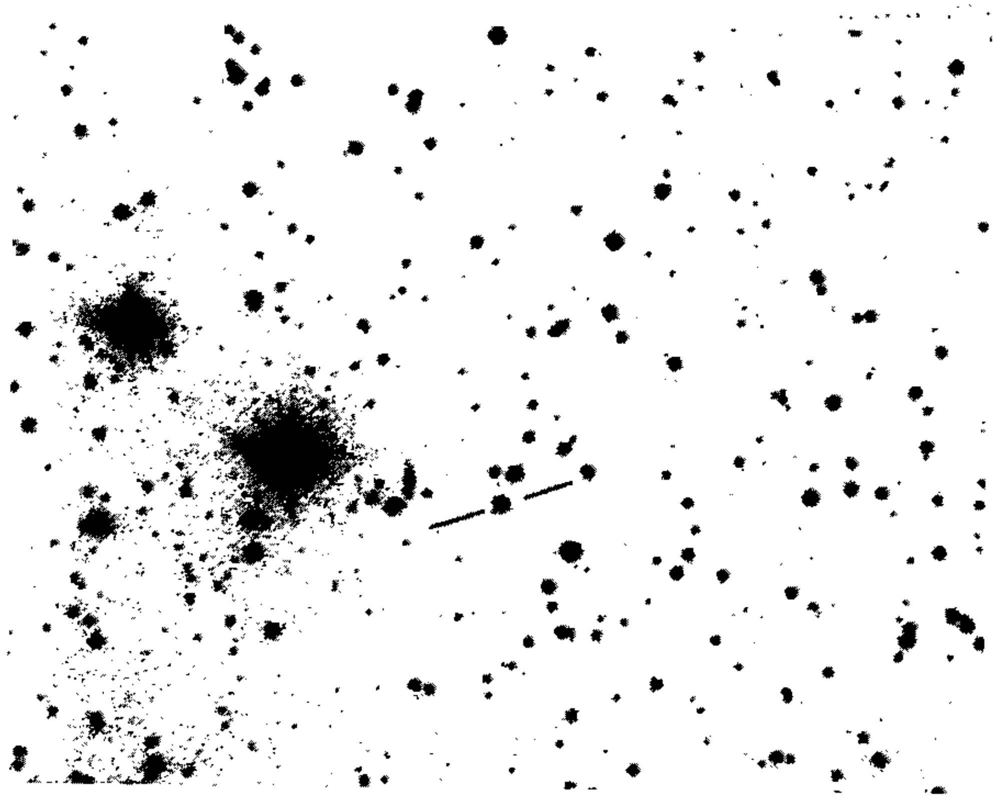

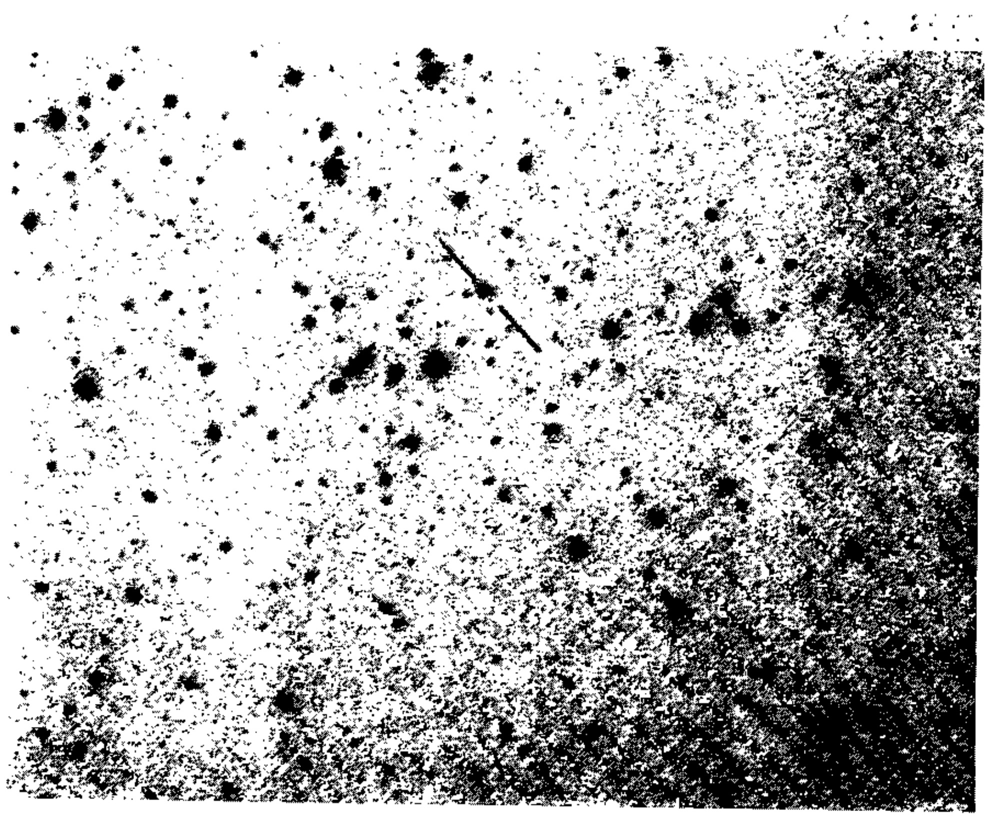

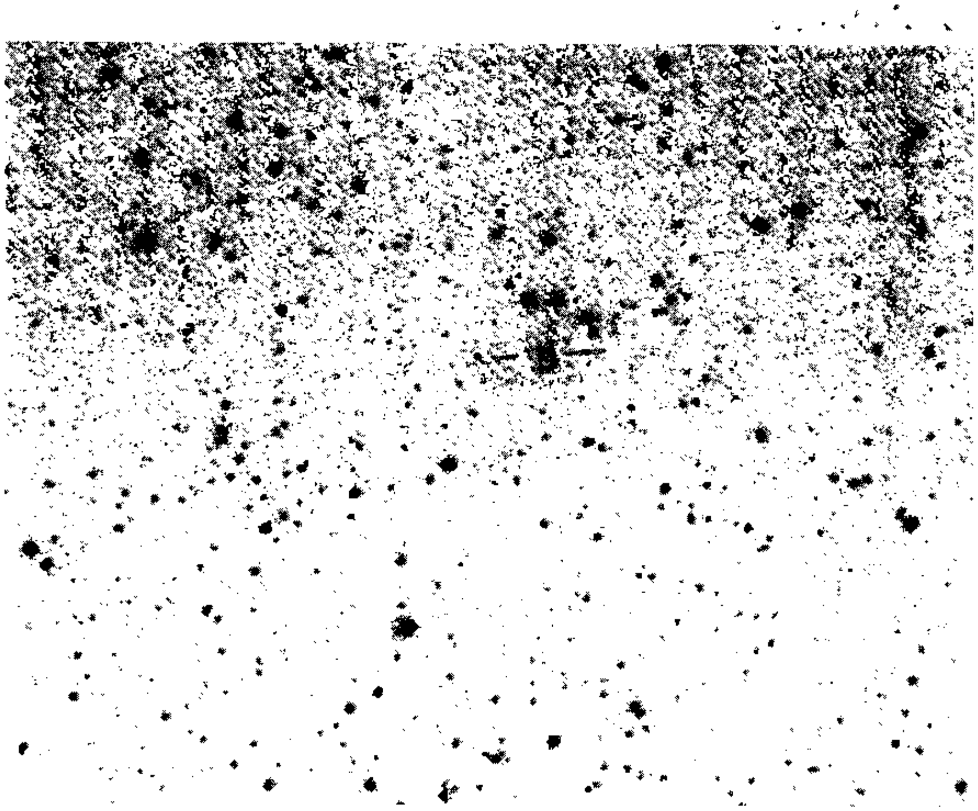

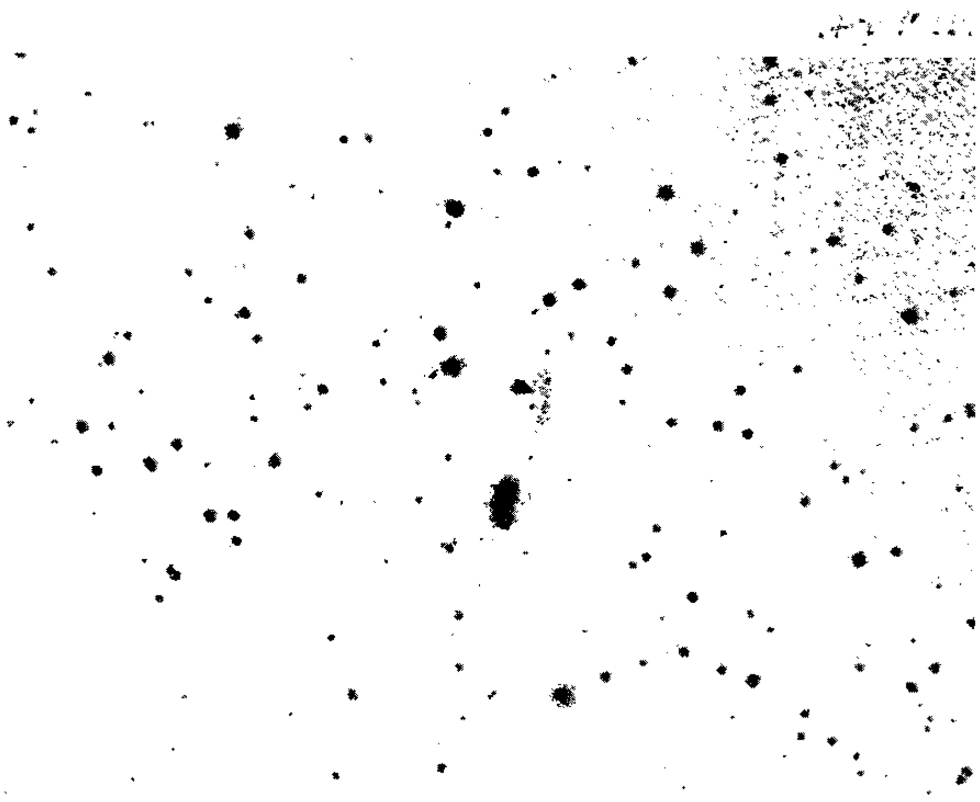

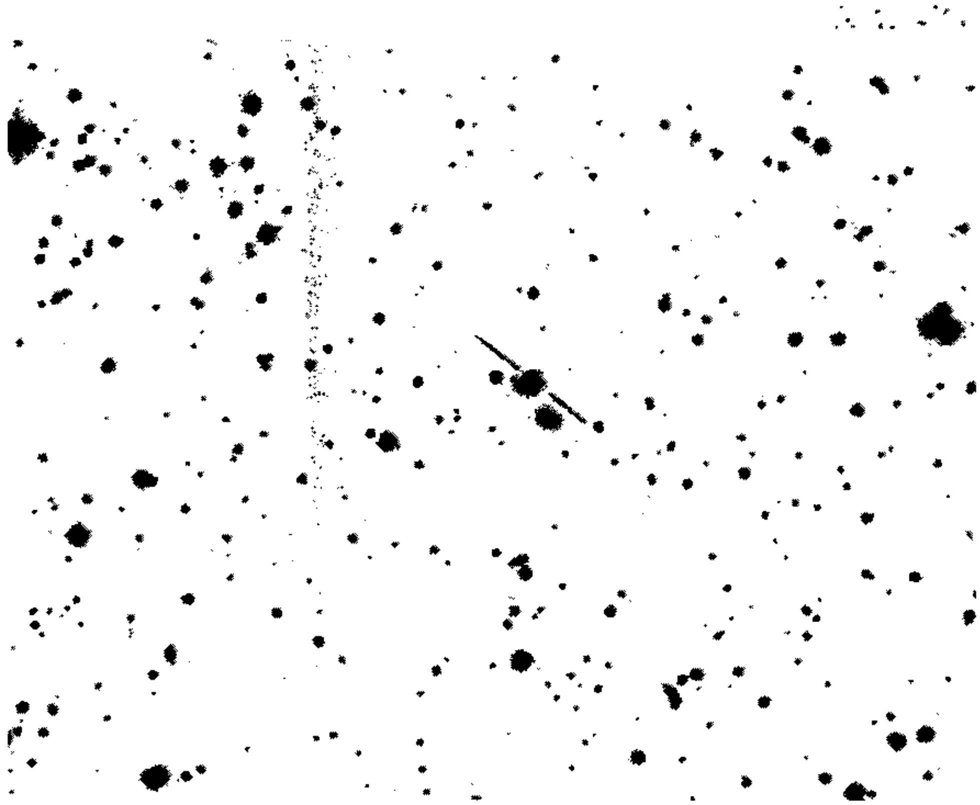

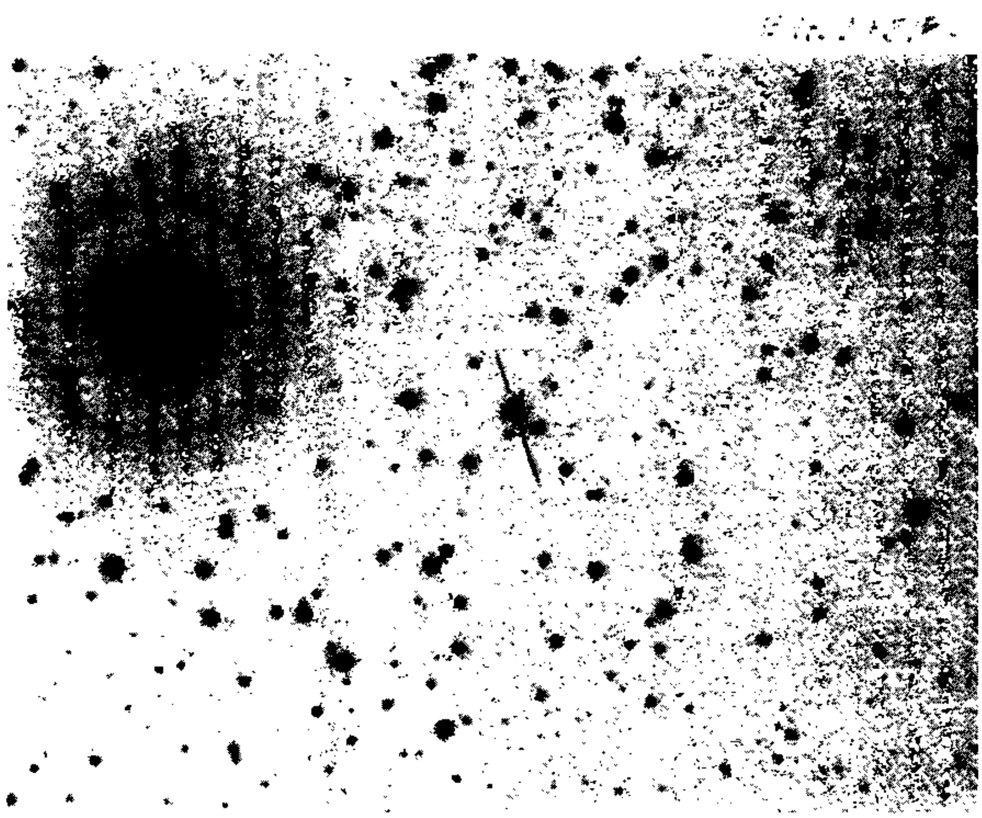

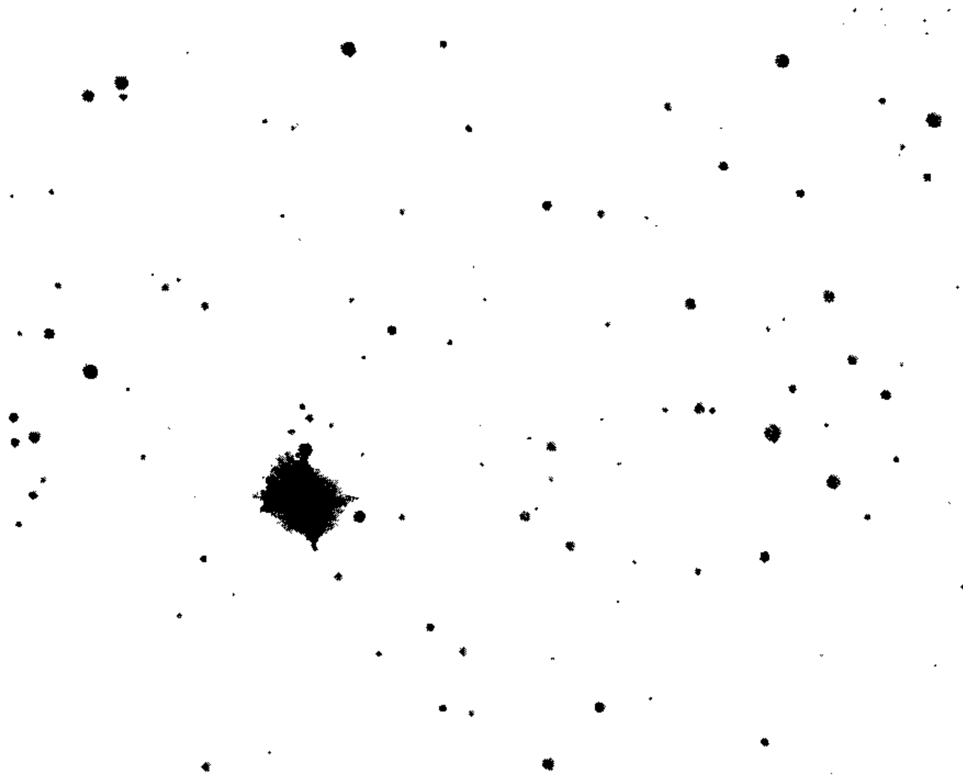

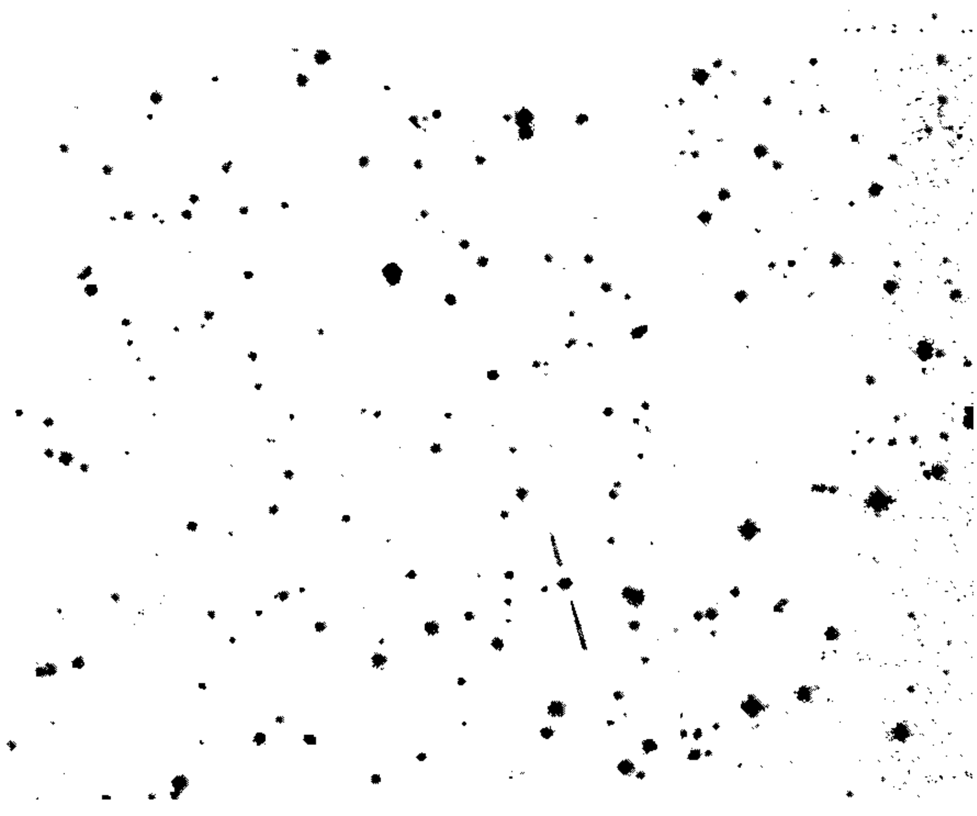

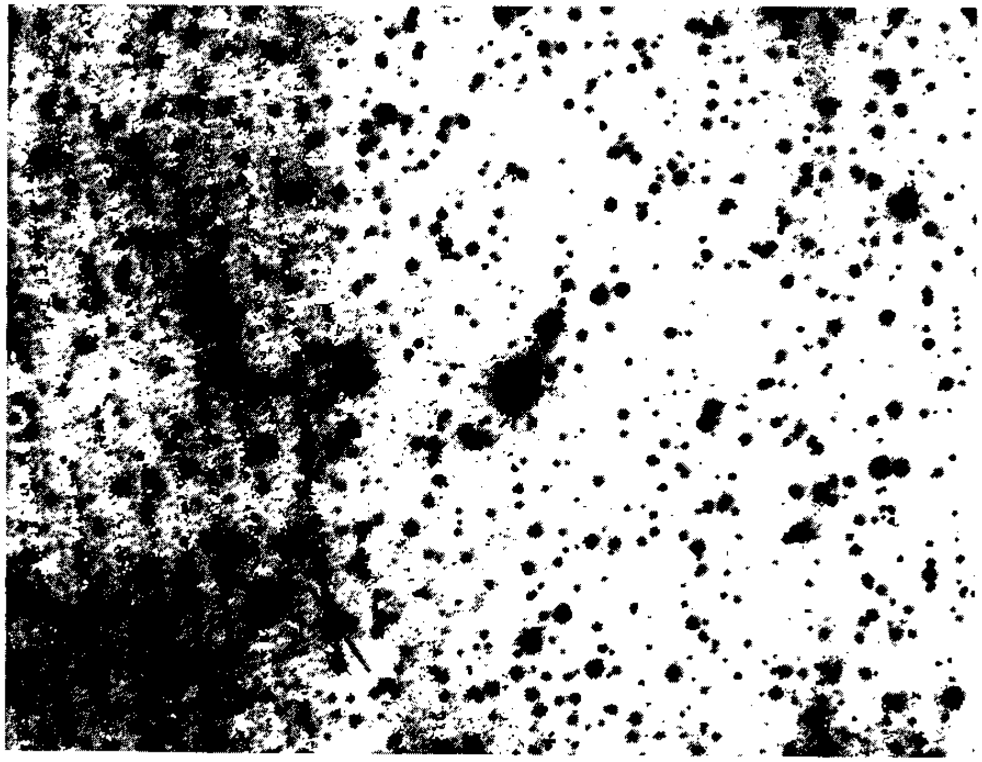

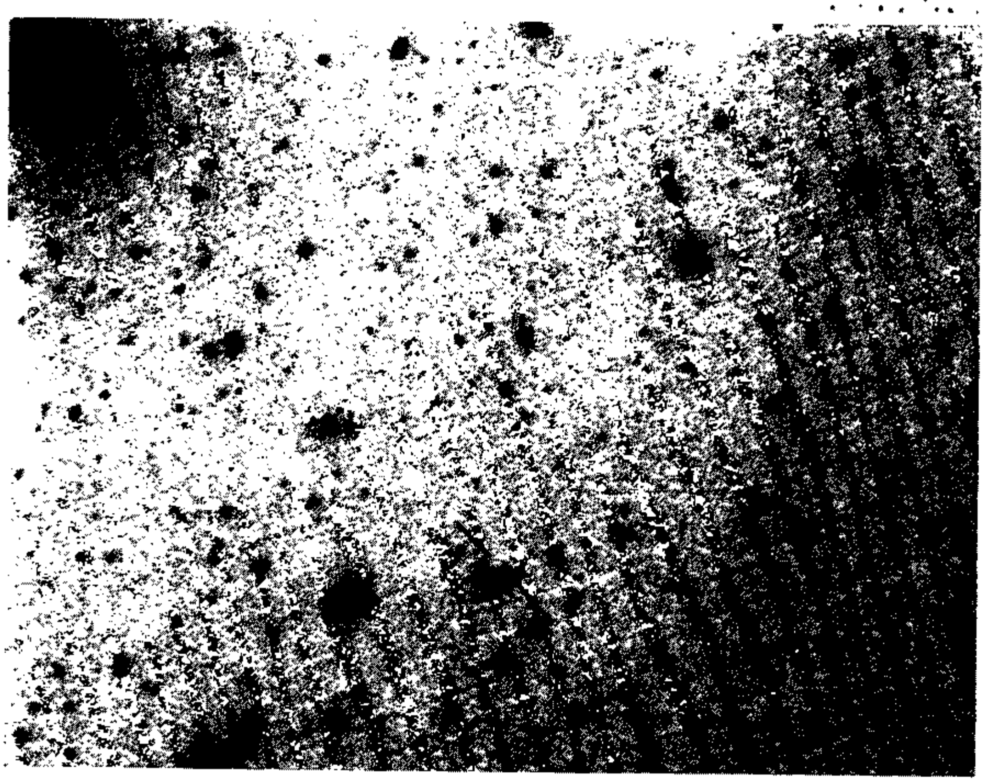

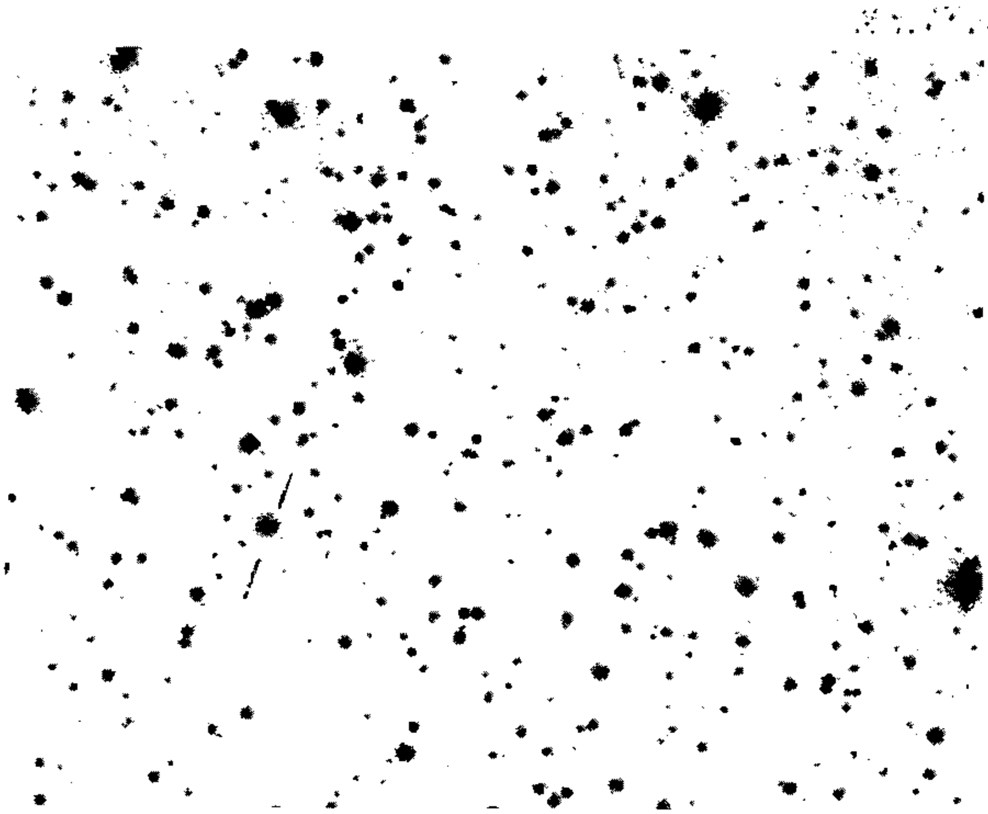

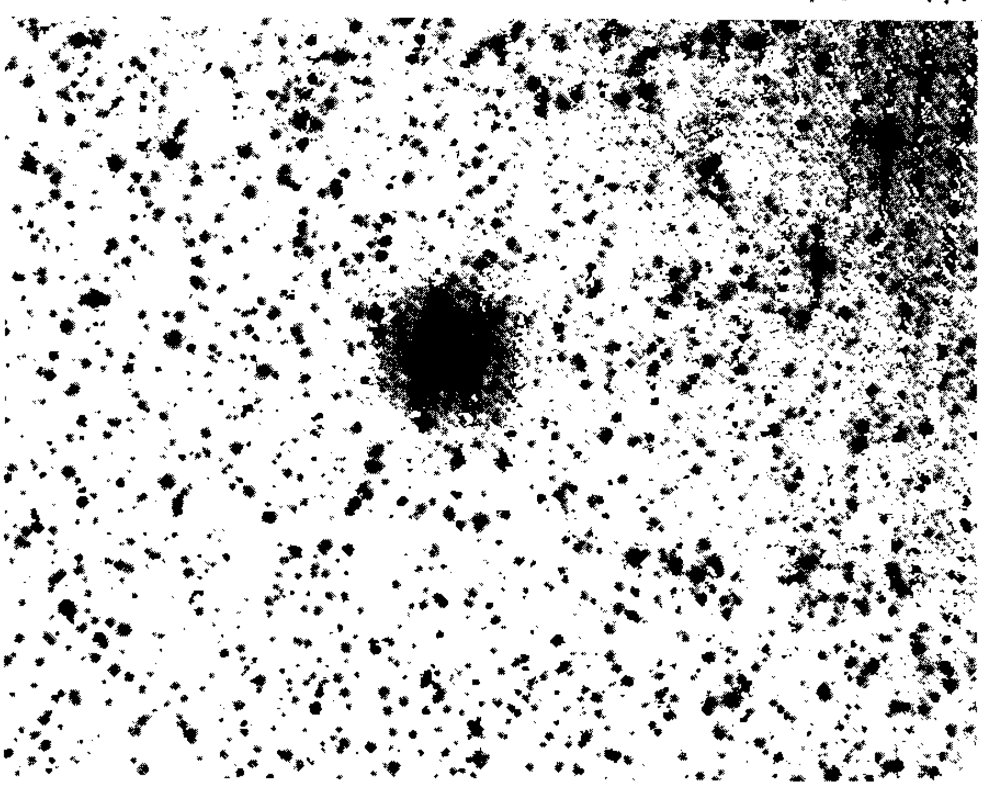

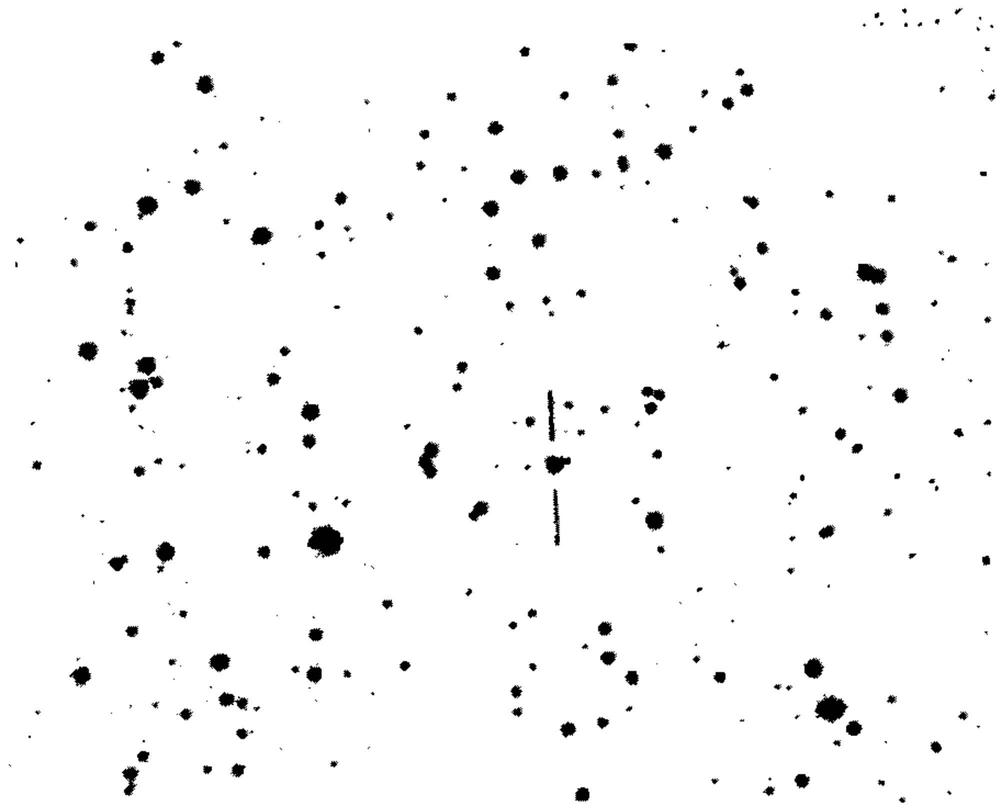

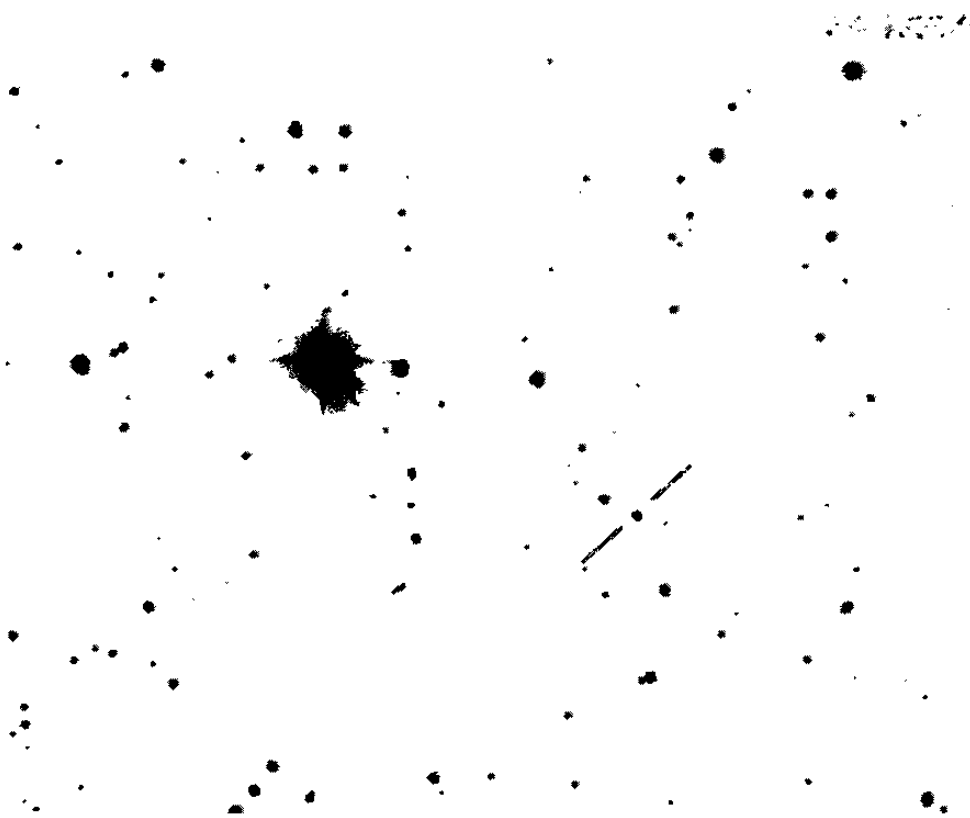

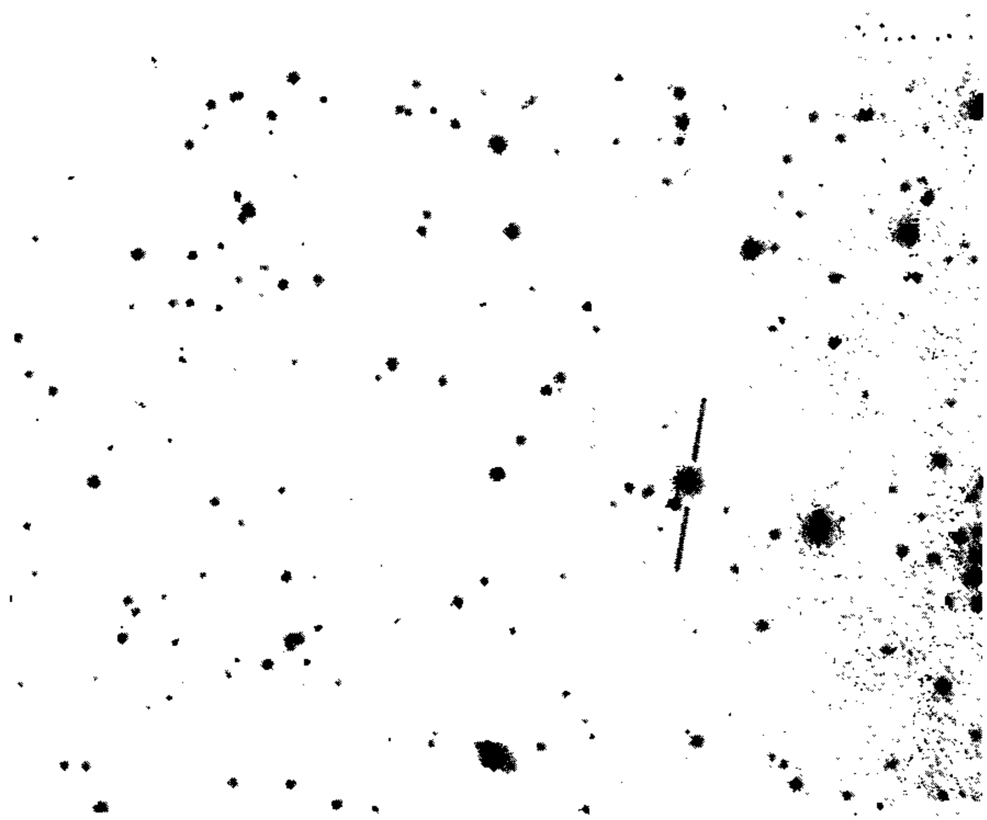

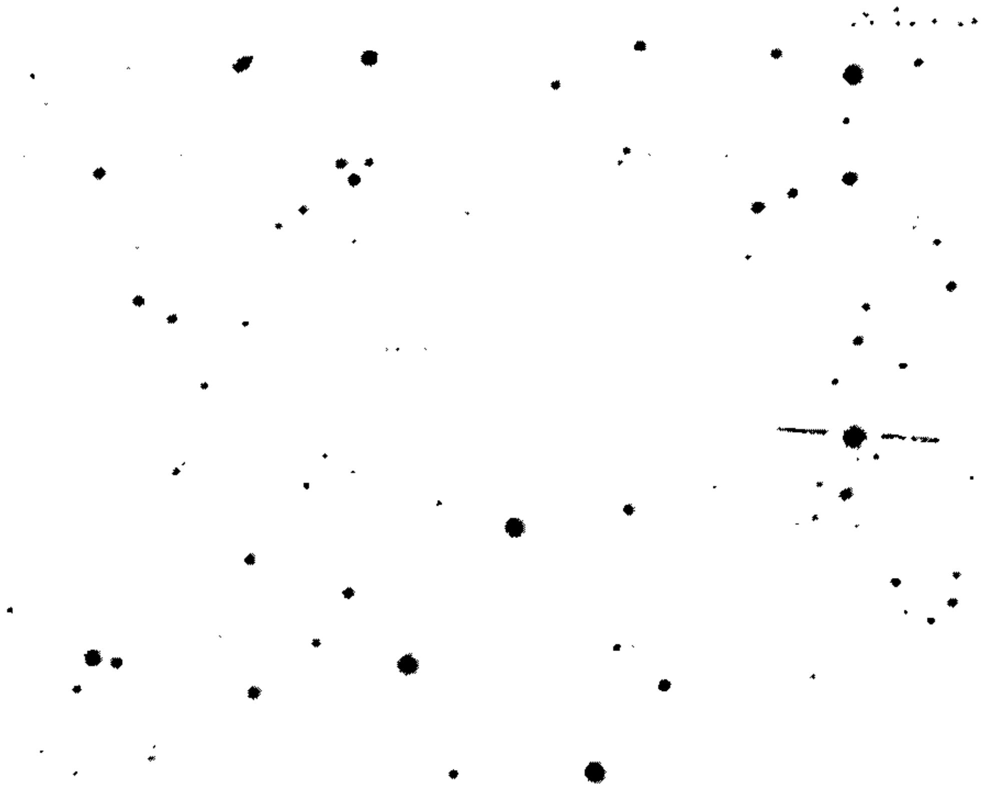

3. Selection of the Objects and Facilities

The present program allows for two alternatives – a minimum and a maximum program.

In the former, 64 objects are included, being in the same time Seyfert galaxies and X-ray sources. Out of the total of 64 objects included therein, 34 are Markarian galaxies. The main data source used was Veron-Cetty and Veron (1985) catalogue.

The minimum program takes in 11 objects, selected in the following way: 98 active galaxies (50% of the total number, on which there are sufficient spectrohotometrical data available), were studied by the method of Aldrovandi (1981). According to this model the black hole's mass and the accretion rate may be reckoned from Hβ line luminosity and the relative intensity of ionized HeI λ4686 HeII/I Hβ, provided all conditions, mentioned under Section 1 are present. Out of 98 objects studied, 47 may have as energy source the accretion disk around a black hole (Petrov and Velichkova, 1988).

Eleven objects, marked with a star (*) in Table I, are at the same time Sy G, X-ray sources, and according to the model of Aldrovandi, have in the nucleus a black hole, surrounded by an accretion disk.

In our opinion, it would be preferable to make as mny as possible current electro-photometrical estimations, and spectrophotometrical data must cover the largest possible wavelength range, say 3700–8000 Å, and have maximum spectral resolution.

4. Expected Results

The contention of the existence of a massive black hole, surrounded by an accretion disk, in active galactic nuclei, is being checked from several different aspects. The observing data could be significant for making precise the models of active galactic nuclei, no matter whether this hypothesis is finally corroborated or rejected.

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