Gas Relations in Comet 1P/Halley

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1. Introduction

- Comet 1P/Halley (1P/1982 U1) was observed photographically from 1986 February 17 to April 17 at the European Southern Observatory (ESO) on La Silla (Chile). Altogether 1,216 images were taken in 57 of consecutive 60 nights.
- Photoelectric photometry of the cometary coma was obtained from February 24 to April 17, 1986.

2. Data

- Combination of camera, emulsion, filter and exposure time
- Camera: FFC, WFC1-4, UVS, BOC, TEL
- Emulsion: TP 2415, 103 a-F, III a-F, II a-O, III a-J
- Filter: OG 530 (dust), CO^+, without filter, GG 410, CN, RG 645, H_2O^+, N_2^+, GG 375 + IF 4634, CO_2^+
- Exposure time: between one second and 170 minutes

- Resolution of the Flat-Field-Camera, FFC:

5'' = 1,700 km

- Resolution of the Wild-Field-Camera, WFC:

30'' = 10,210 km

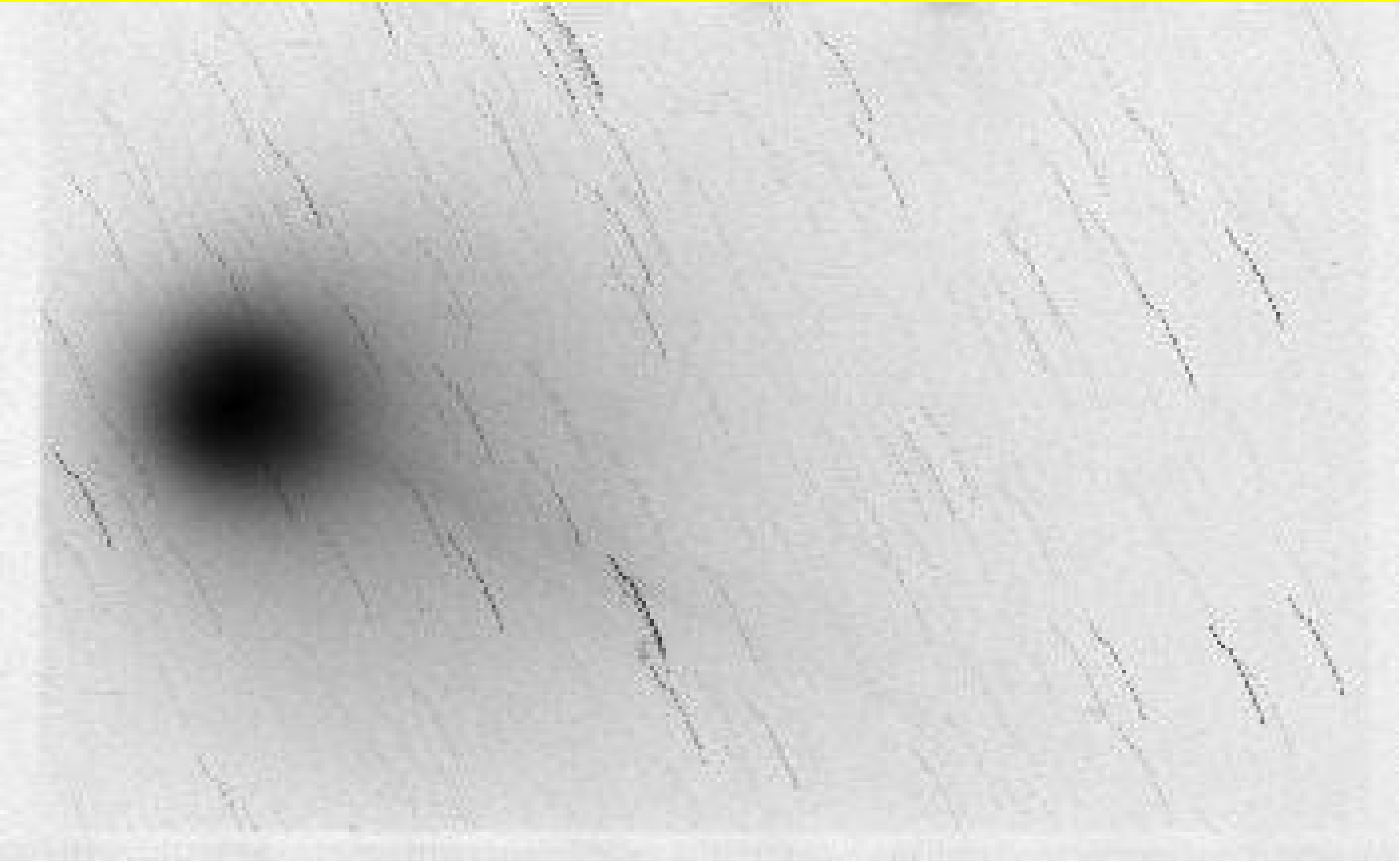
(Celnik & Schmidt-Kaler 1987)

3. Analysis of the Structures in Coma and in Tail

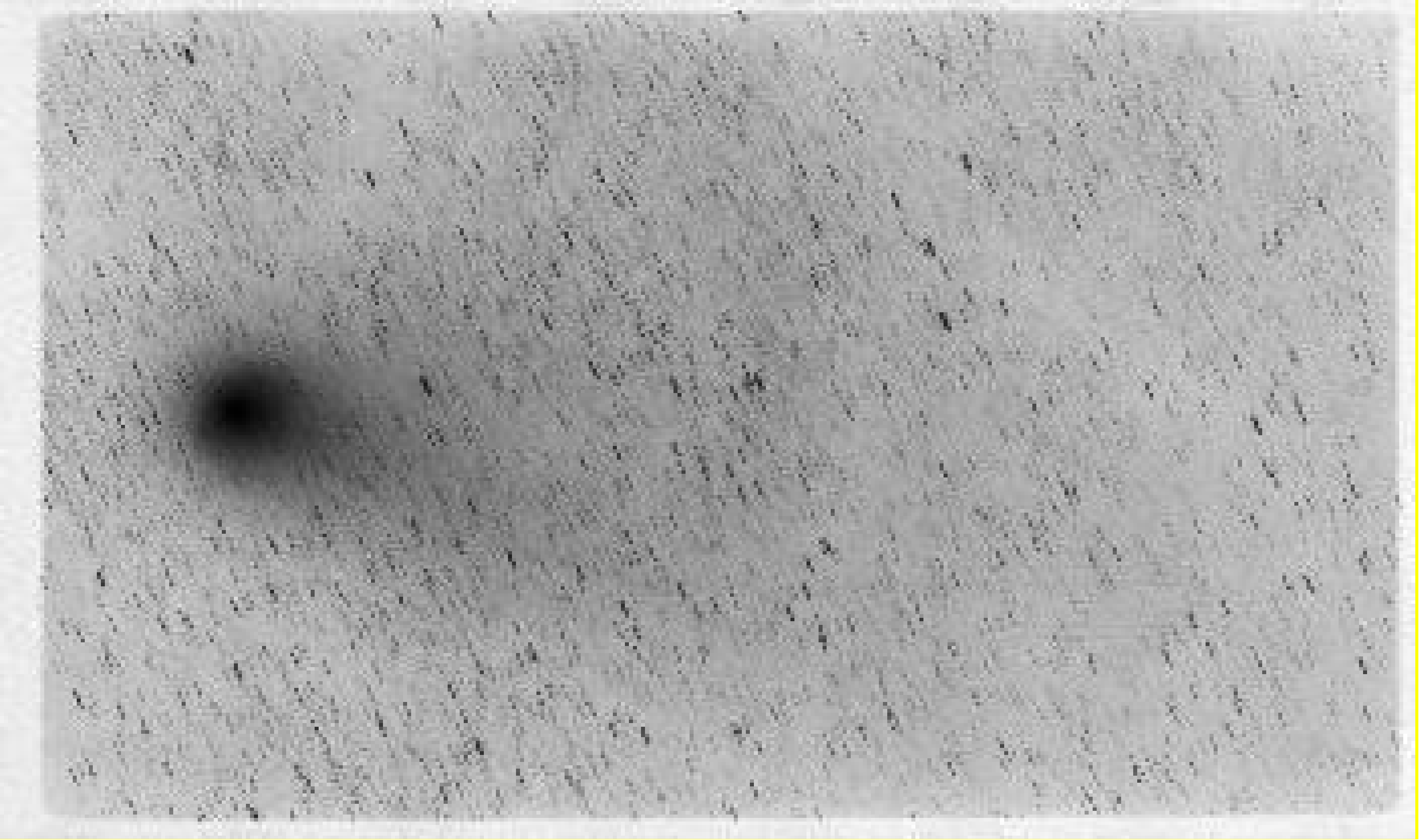
- *Jets*
- *Arcs*
- Disconnection events
- Knots
- Wavy structures, undulations, train of waves
- Solitary waves, solitons, kinks
- Swan-like tails
- Anti-tails

1P/Halley 07.04.1986 / CO^+ / 50^m

1P/Halley 07.04.1986 / CN / 80^m

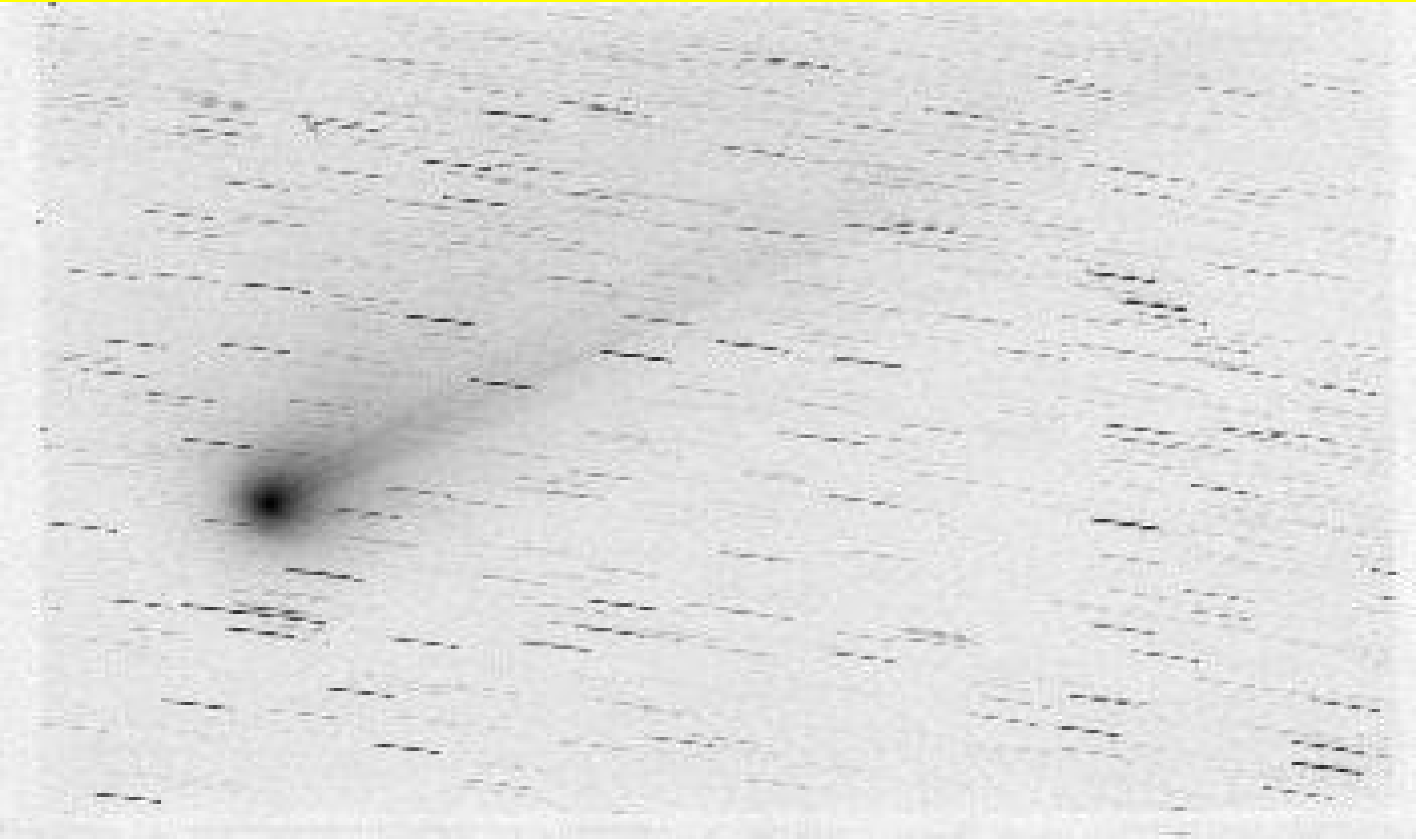


1P/Halley 07.04.1986 / Dust / 12^m

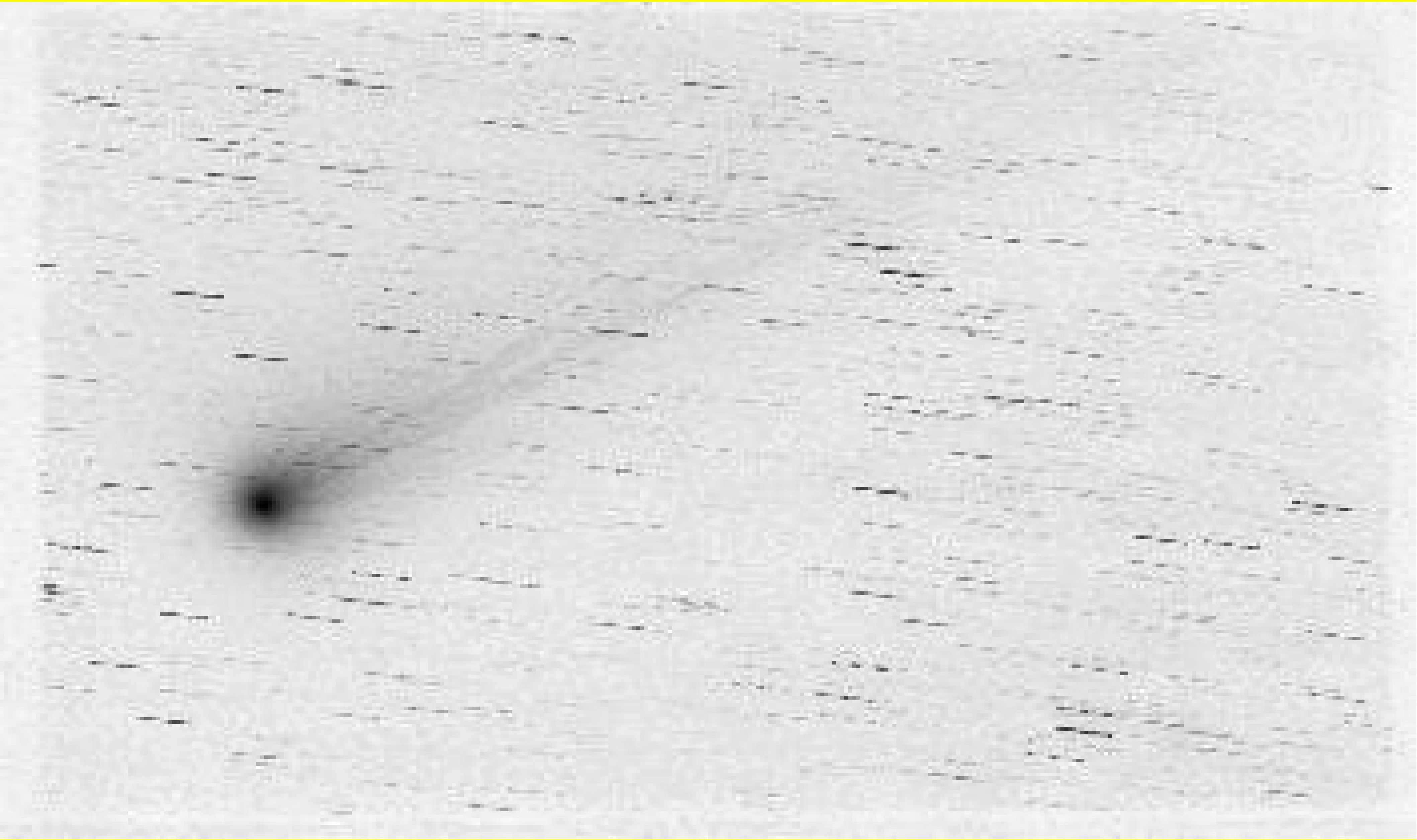


1P/Halley 07.04.1986 / CN / 1^m

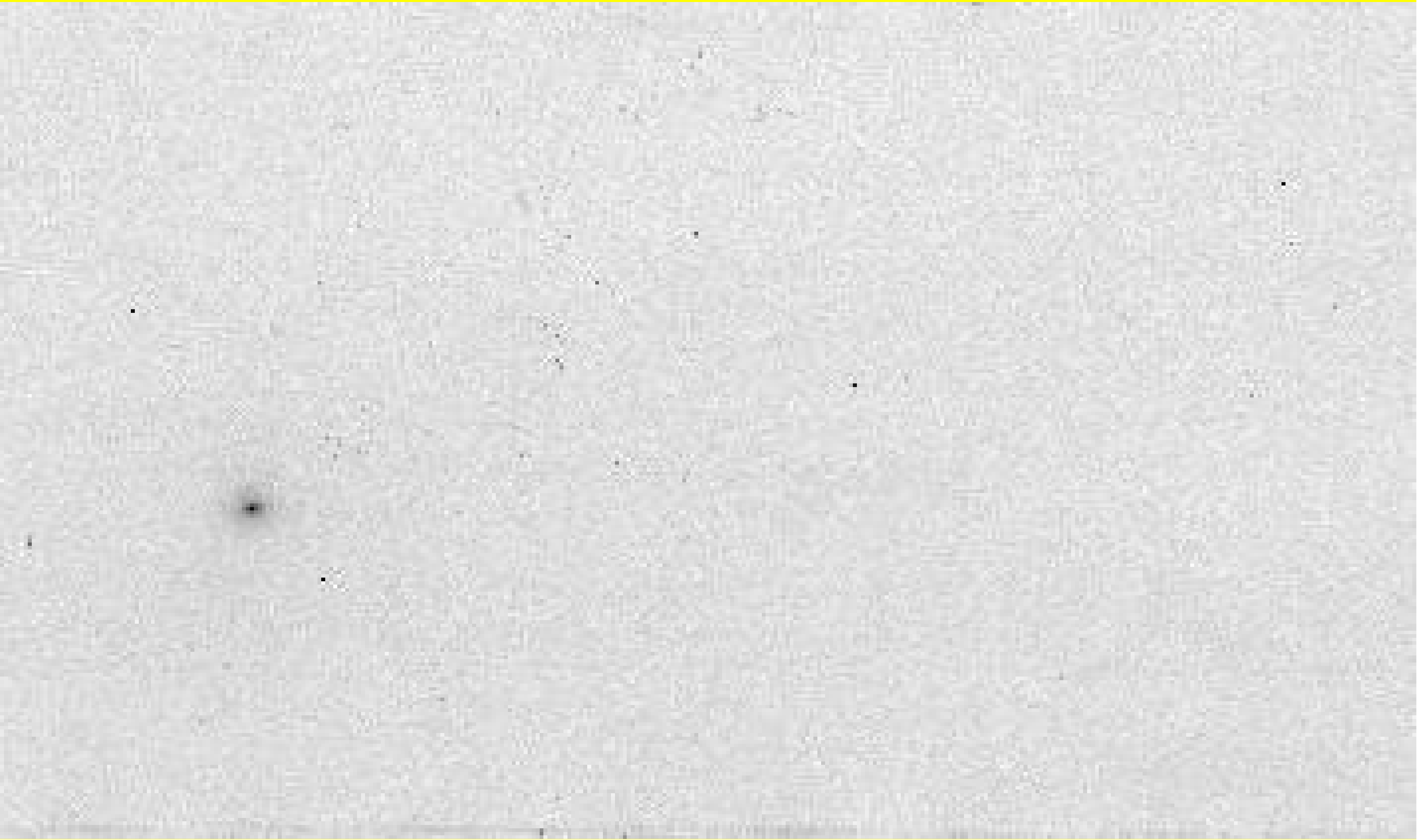
1P/Halley 06.04.1986 / CO^+ / 50^m



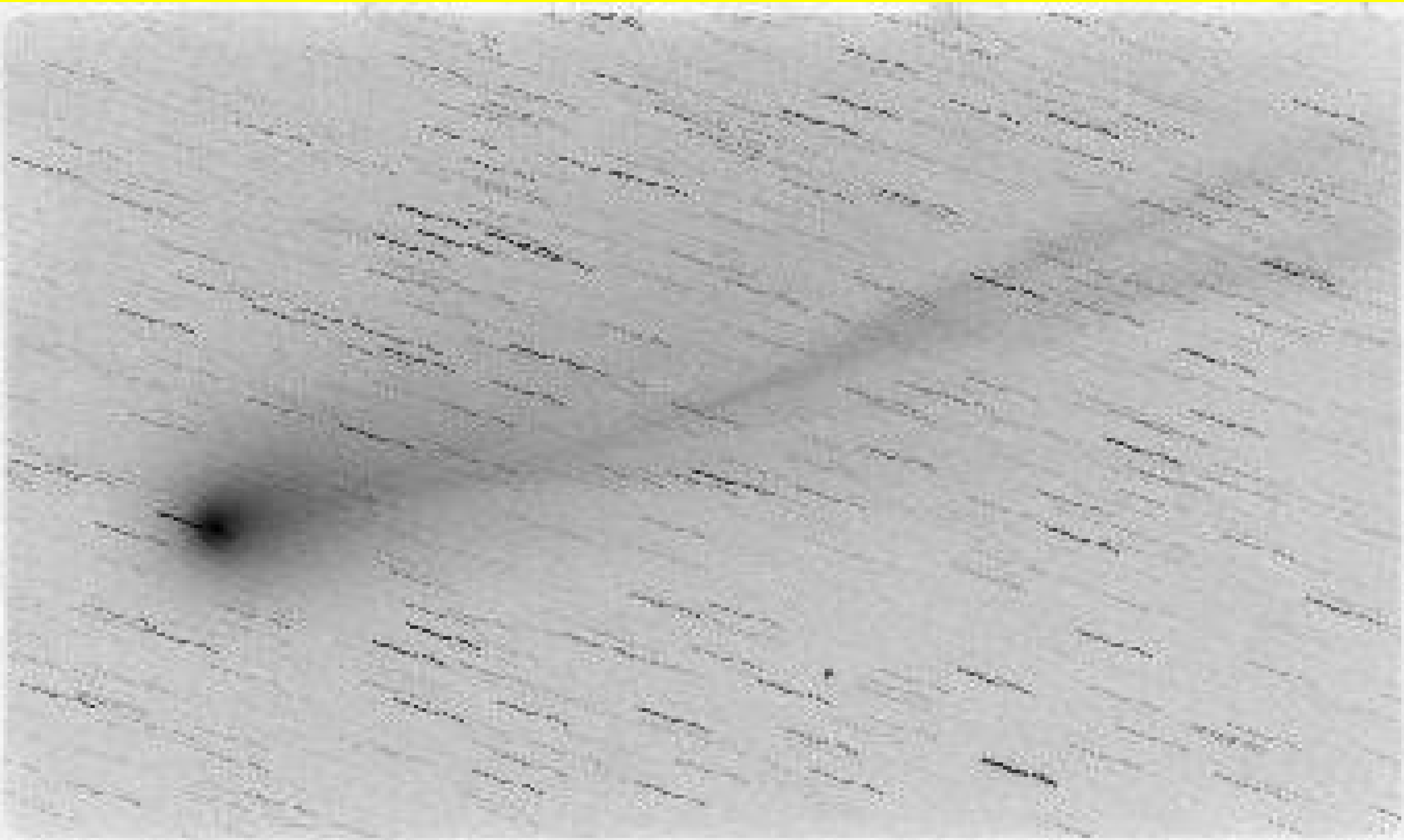
1P/Halley 06.04.1986 / CO^+ / 40^m



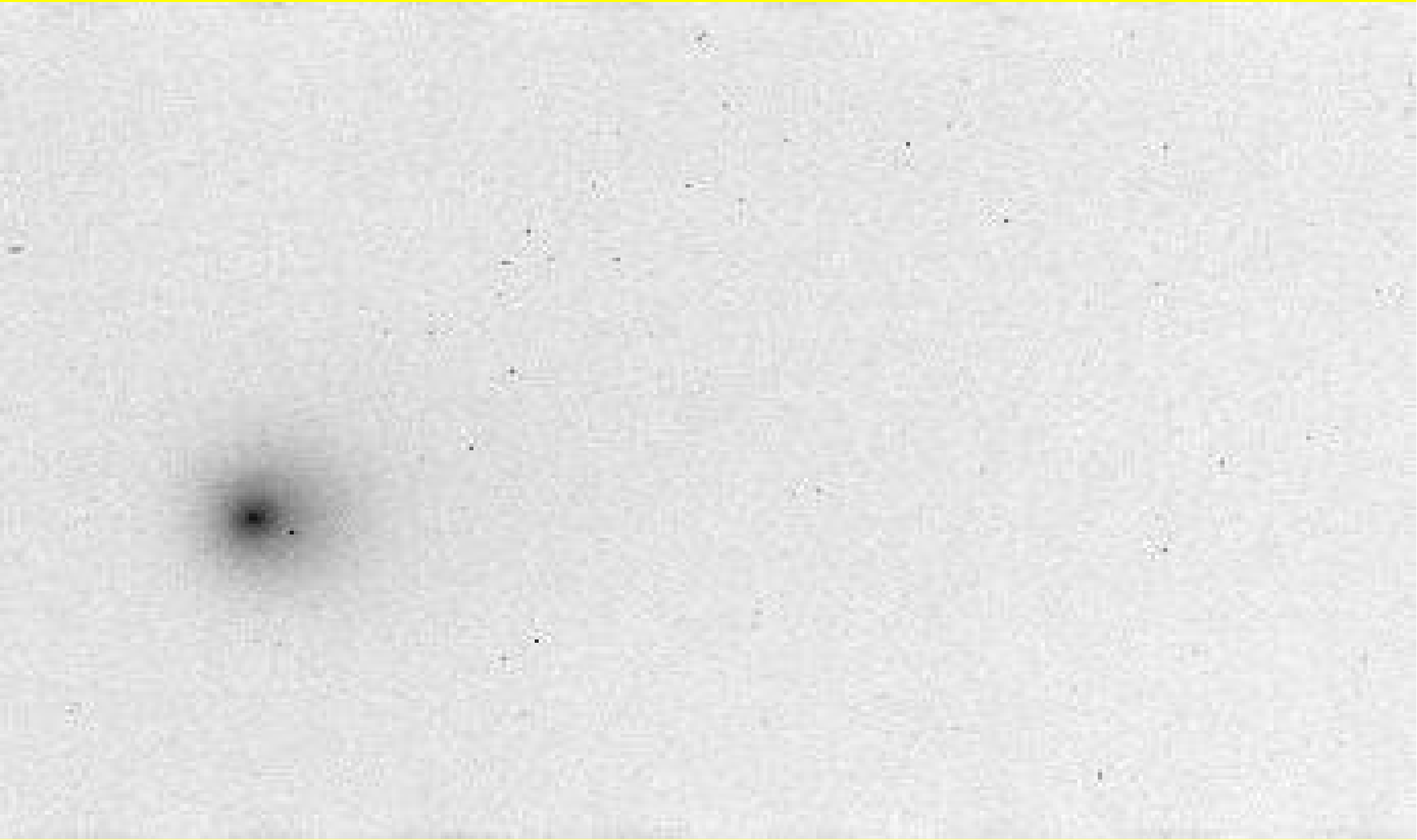
1P/Halley 05.04.1986 / CN / 1^m



1P/Halley 03.04.1986 / CO^+ / 60^m



1P/Halley 03.04.1986 / CN / 4^m

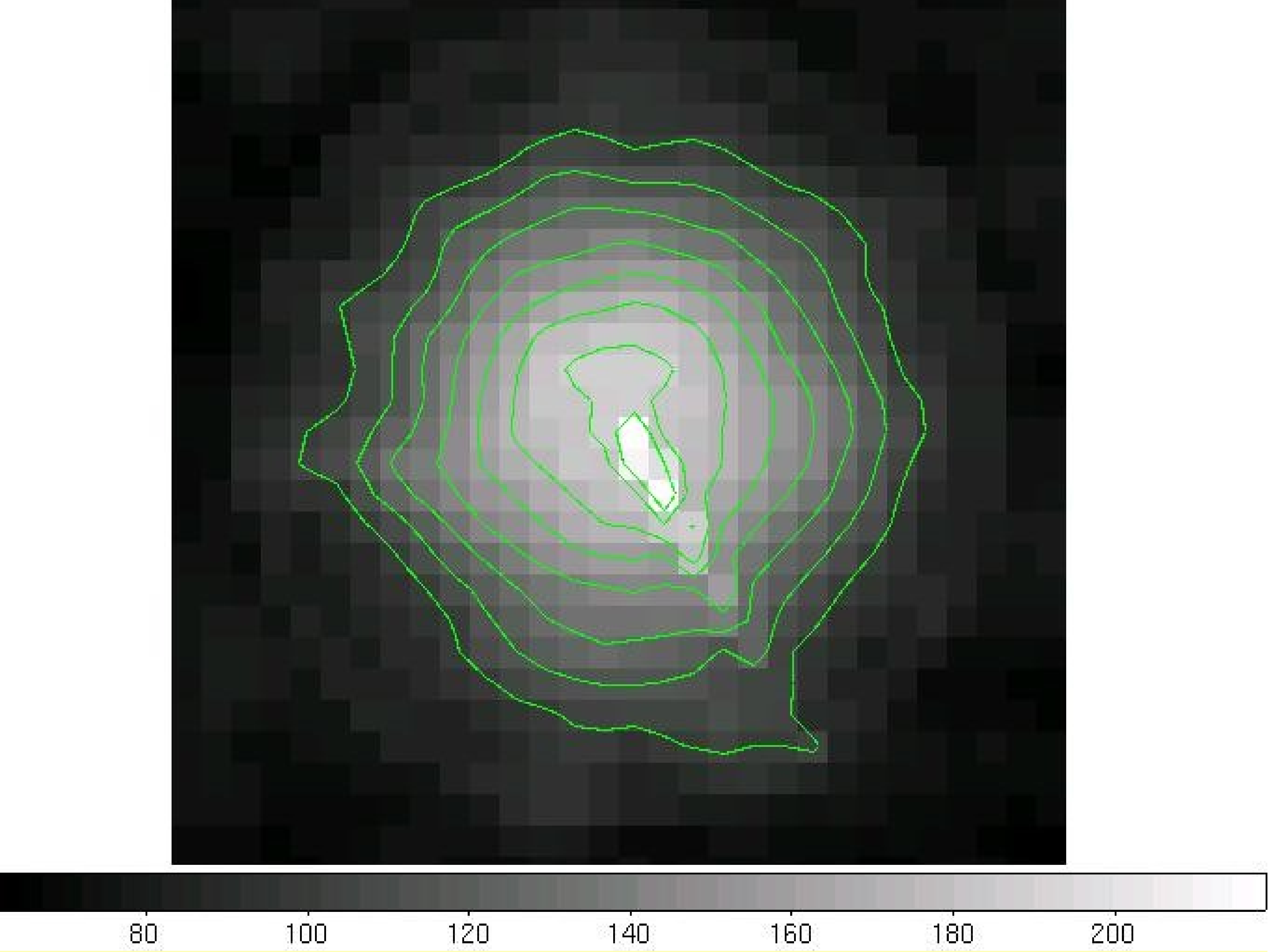


4. Statistic

- February 1986 – 120 cometary images
- 0 disconnection event (0.0%)
- 0 knot (0.0%)
- 3 wavy structures (2.5%)
- 0 Swan-like tail (0.0%)
- 13 solitary waves (10.8%)
- 30 jets (25.0%)
- 0 arc (0.0%)
- 12 anti-tails (10.0%)

- March 1986 – 271 cometary images
- 1 disconnection event (0.4%)
- 16 knots (5.9%)
- 29 wavy structures (10.7%)
- 3 Swan-like tails (1.1%)
- 10 solitary waves (3.7%)
- 115 jets (42.4%)
- 0 arc (0,0%)
- 0 anti-tail (0.0%)

- April 1986 – 383 cometary images
- 45 disconnection events (11.8%)
- 68 knots (17.8%)
- 87 wavy structures (22.7%)
- 3 Swan-like tails (0.8%)
- 4 solitary waves (1.0%)
- 99 jets (25.8%)
- 4 arcs (1.0%)
- 0 anti-tail (0.0%)



80
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160
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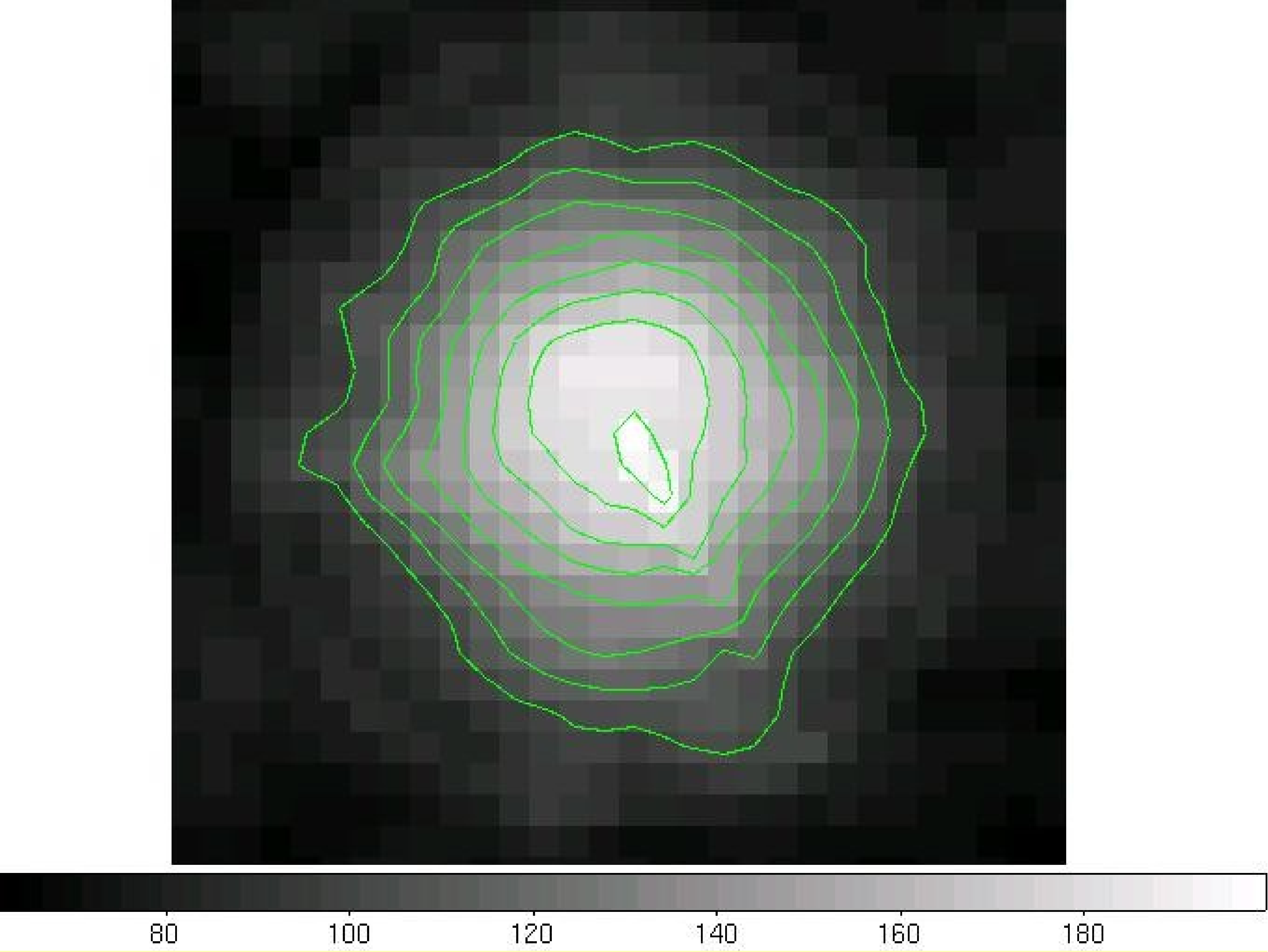

80
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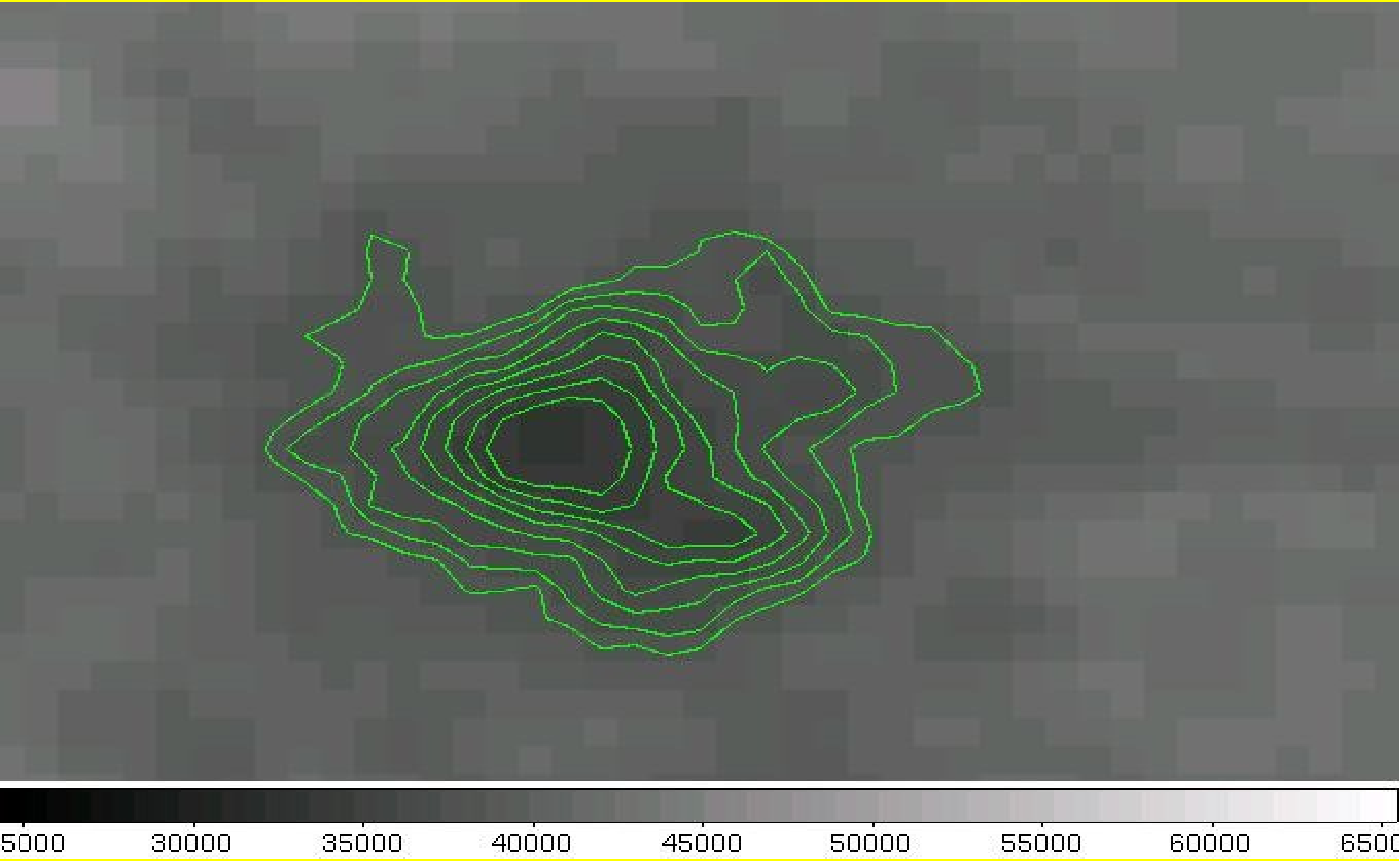
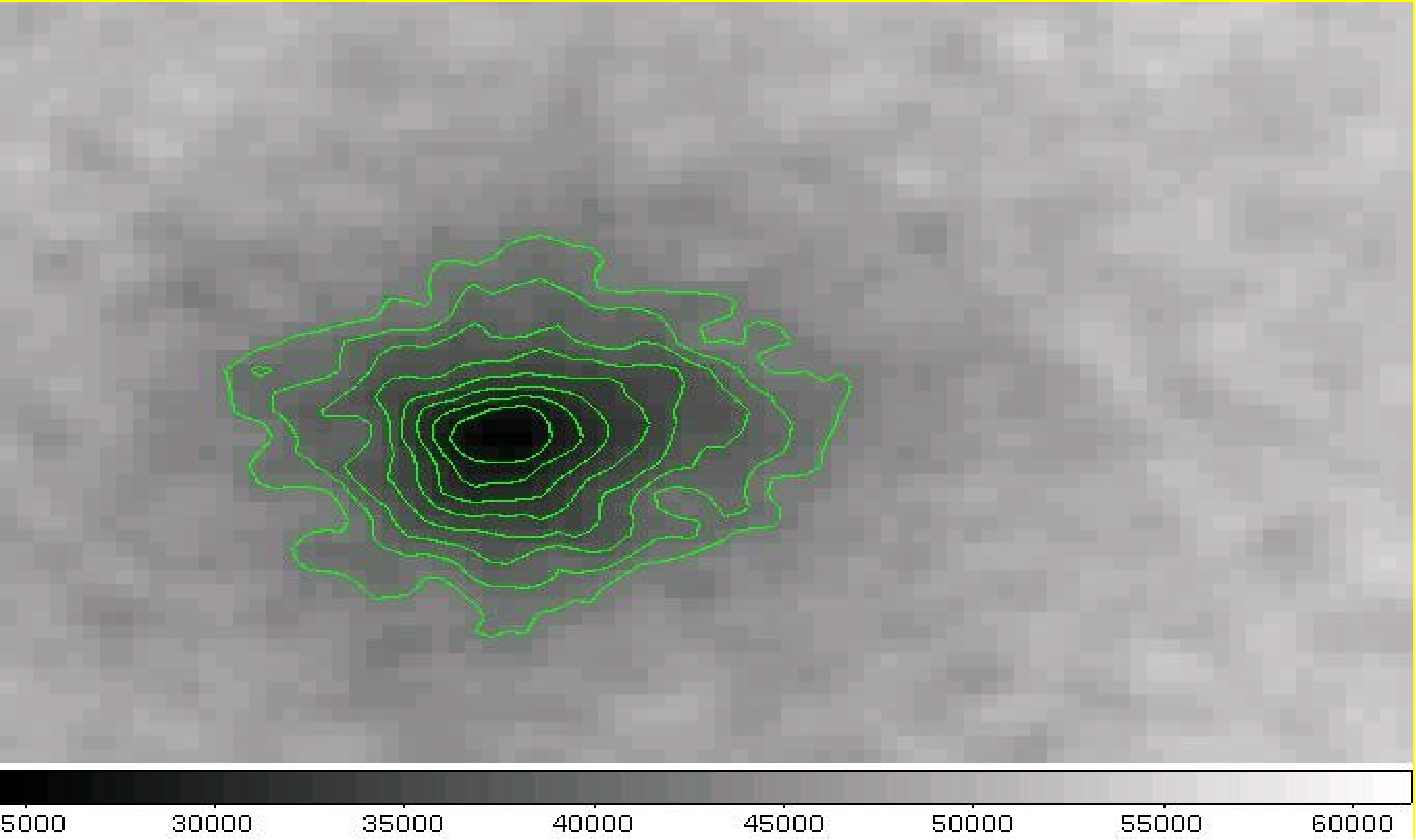
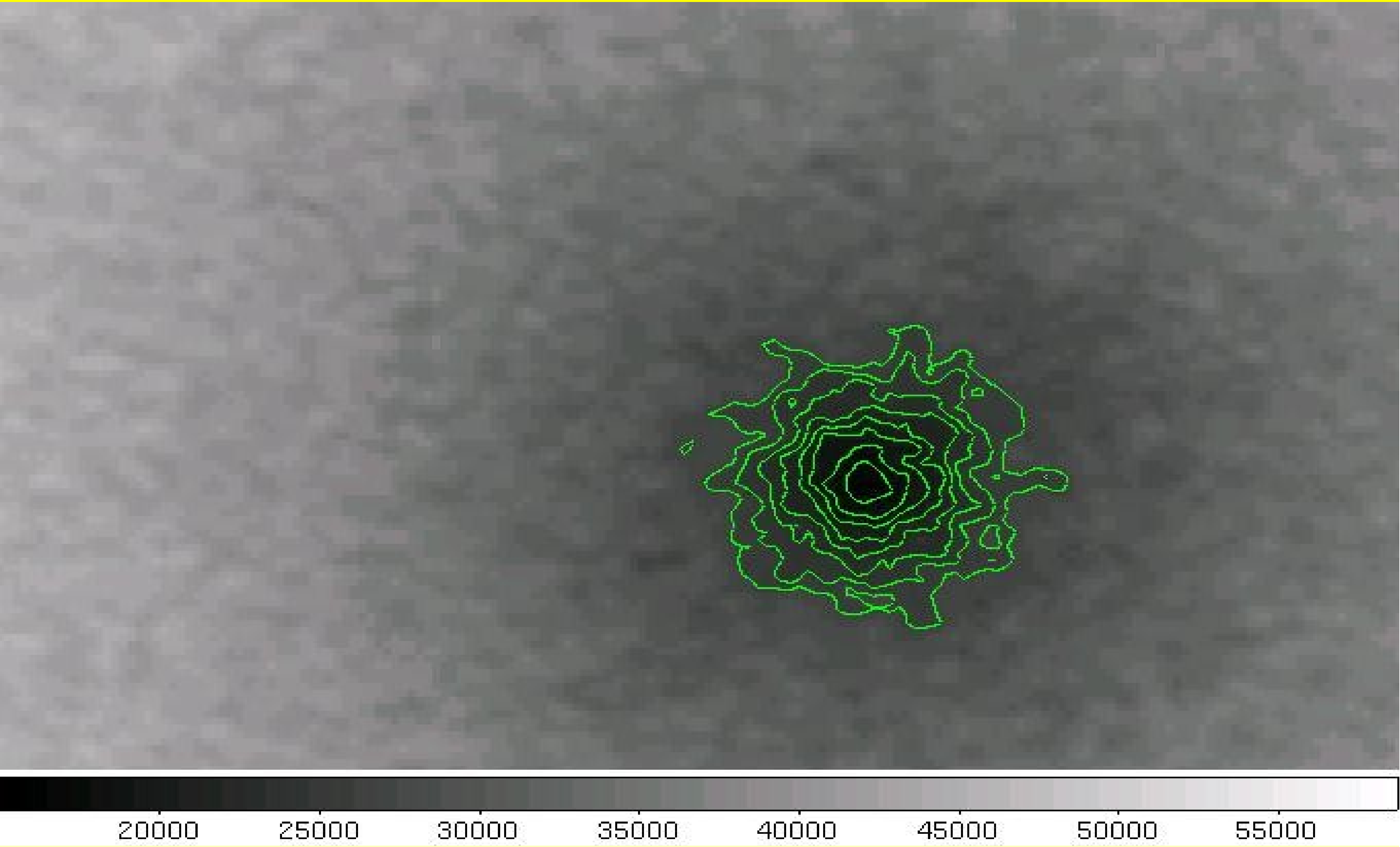
1P/Halley 07.04.1986 / CN / 1^m



1P/Halley 05.04.1986 / CN / 1^{m}

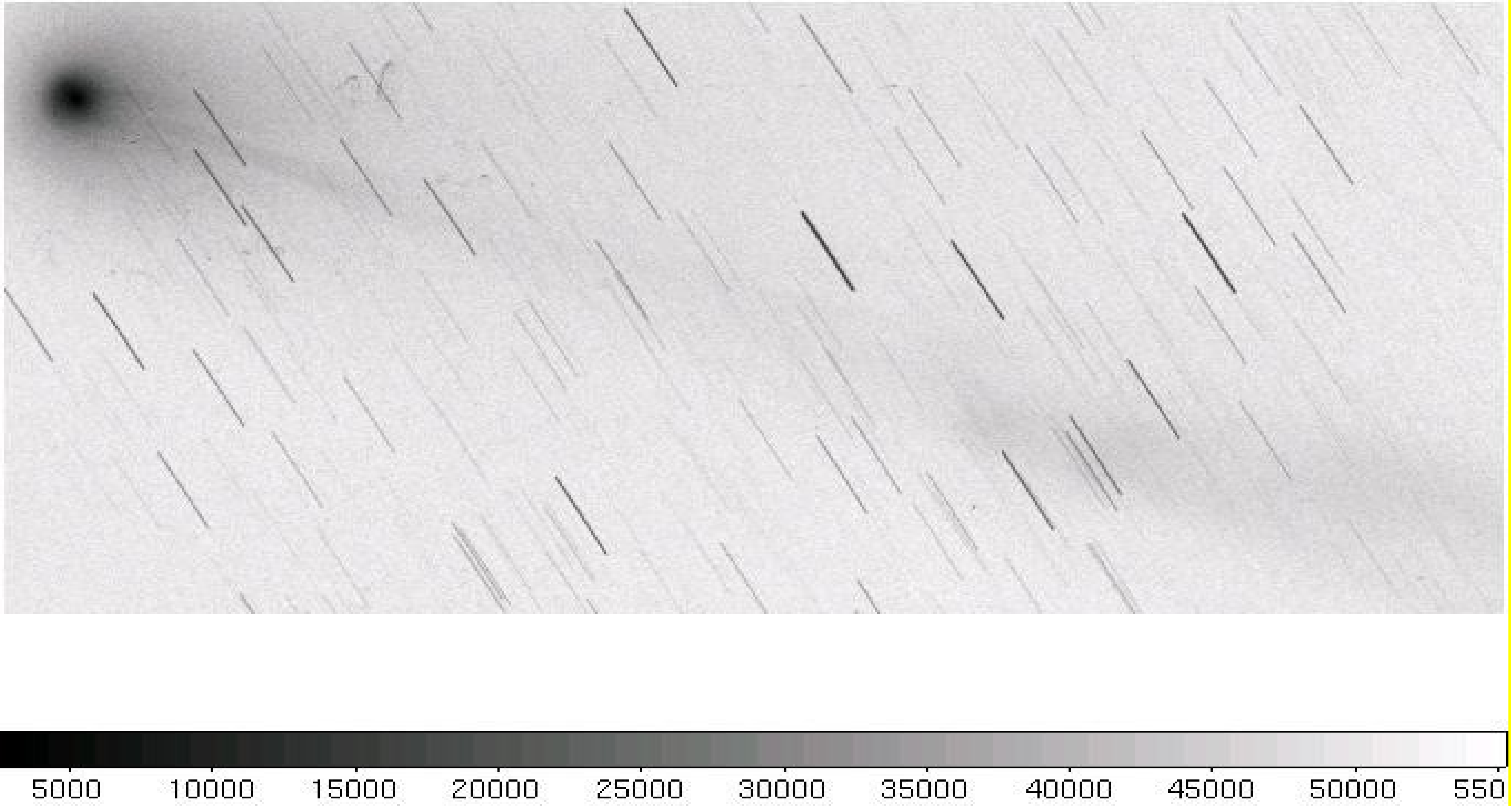


1P/Halley 03.04.1986 / CN / 4^{m}



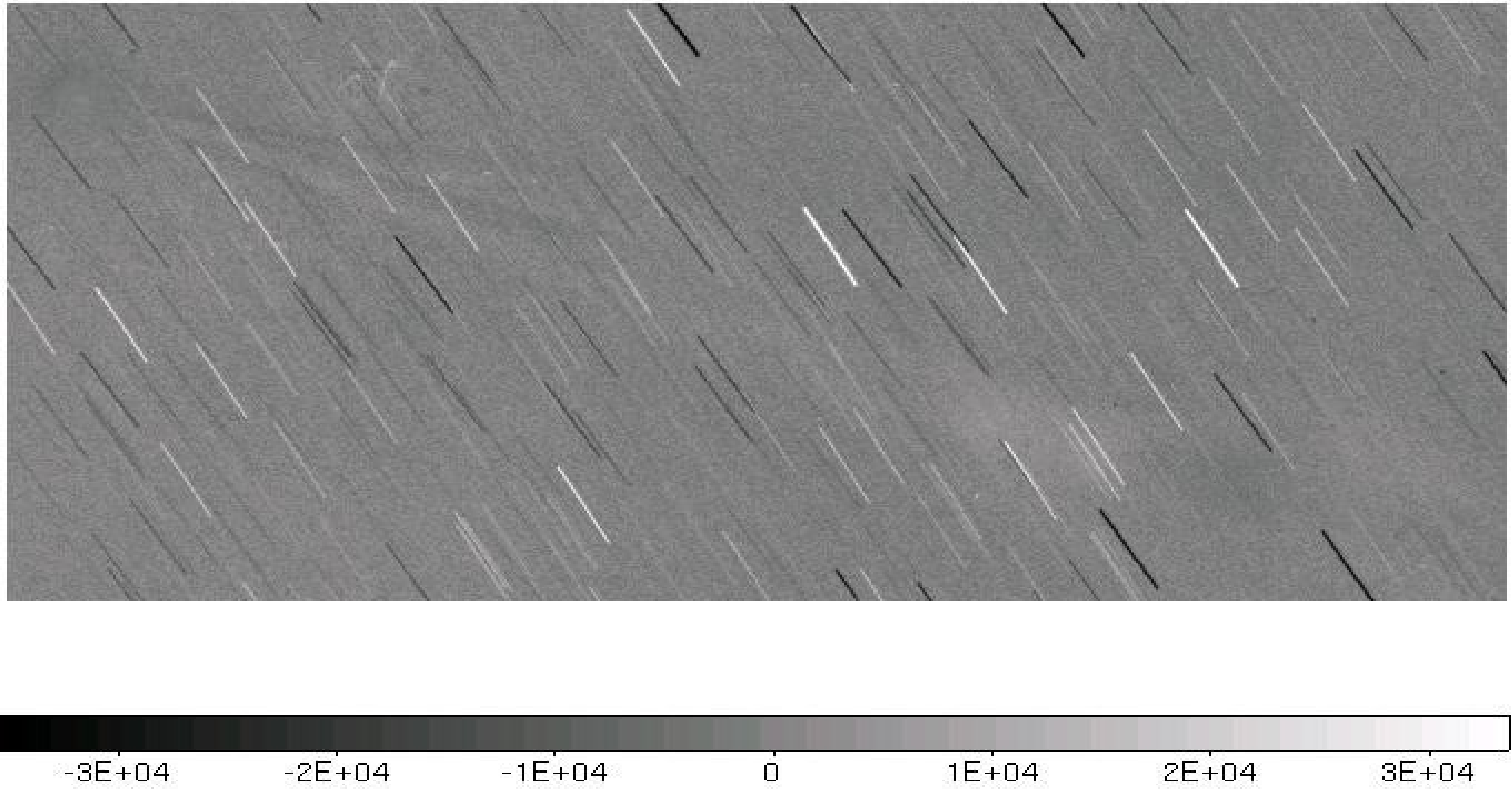
1P/Halley 22.02.1986 / Dust / 15^m

1P/Halley 08.04.1986 / CO^+ / 50^m / 03:53 UT



1P/Halley 08.04.1986 / CO^+ / 50^m / 06:23 UT

1P/Halley difference image Δt = 02:30 St



5. The Cinematic

- In CO^+ coma
- Two knots on 08.04.1986
- Image 5732 – Position $S_1 = 1.60 \times 10^6$ km
- Image 5751 – Position $S_2 = 1.96 \times 10^6$ km
- Time difference: 13,260 seconds
- $V_M = 27.15$ km s^{-1}
- $a = 0.21 \times 10^{-3}$ km s^{-2}

- Two knots on 14.04.1986
- Image 5913 – Position $S_1 = 1.20 \times 10^6$ km
- Image 5949 – Position $S_2 = 1.44 \times 10^6$ km
- Time difference: 14,340 seconds
- $V_M = 16.74$ km s^{-1}
- $a = 0.11 \times 10^{-3}$ km s^{-2}

6. Period Analysis

- The analysis of the CO^+ morphological structures in the difference images resulted, with the use of the phase dispersion minimization (PDM) procedure, in a nuclear cometary rotation period of (2.22 ± 0.09) days.
- The analysis of the digitalized CN images resulted (7.37 ± 0.16) days.

- Based on these both periods a lot of different models, that consider the rotation and the precession of the nucleus, were developed.
- To explain these different results a composition between the rotation of 7.4 days around one of the both short axes and the precession of 2.2 days around the long axe of the comet can be considered.

7. Results of the Calibration of the Plasma Images

Table 1. CO^+ Plasma images absolute intensities

Date	Image	Decimal Day (in April 1986)	Absolute Intensity (in 10^{-9} erg s^{-1} cm^{-2})
01.04.1986	5530	1.340	1.405
02.04.1986	5546	2.252	1.269
02.04.1986	5556	2.304	1.108
04.04.1986	5602	4.239	0.868
04.04.1986	5619	4.335	0.672
06.04.1986	5675	6.243	1.473
06.04.1986	5685	6.339	1.316
07.04.1986	5693	7.090	1.103
07.04.1986	5716	7.255	1.158
08.04.1986	5732	8.094	0.691
08.04.1986	5751	8.248	1.233
13.04.1986	5881	13.234	2.229
14.04.1986	5913	14.057	0.606
14.04.1986	5949	14.223	0.621

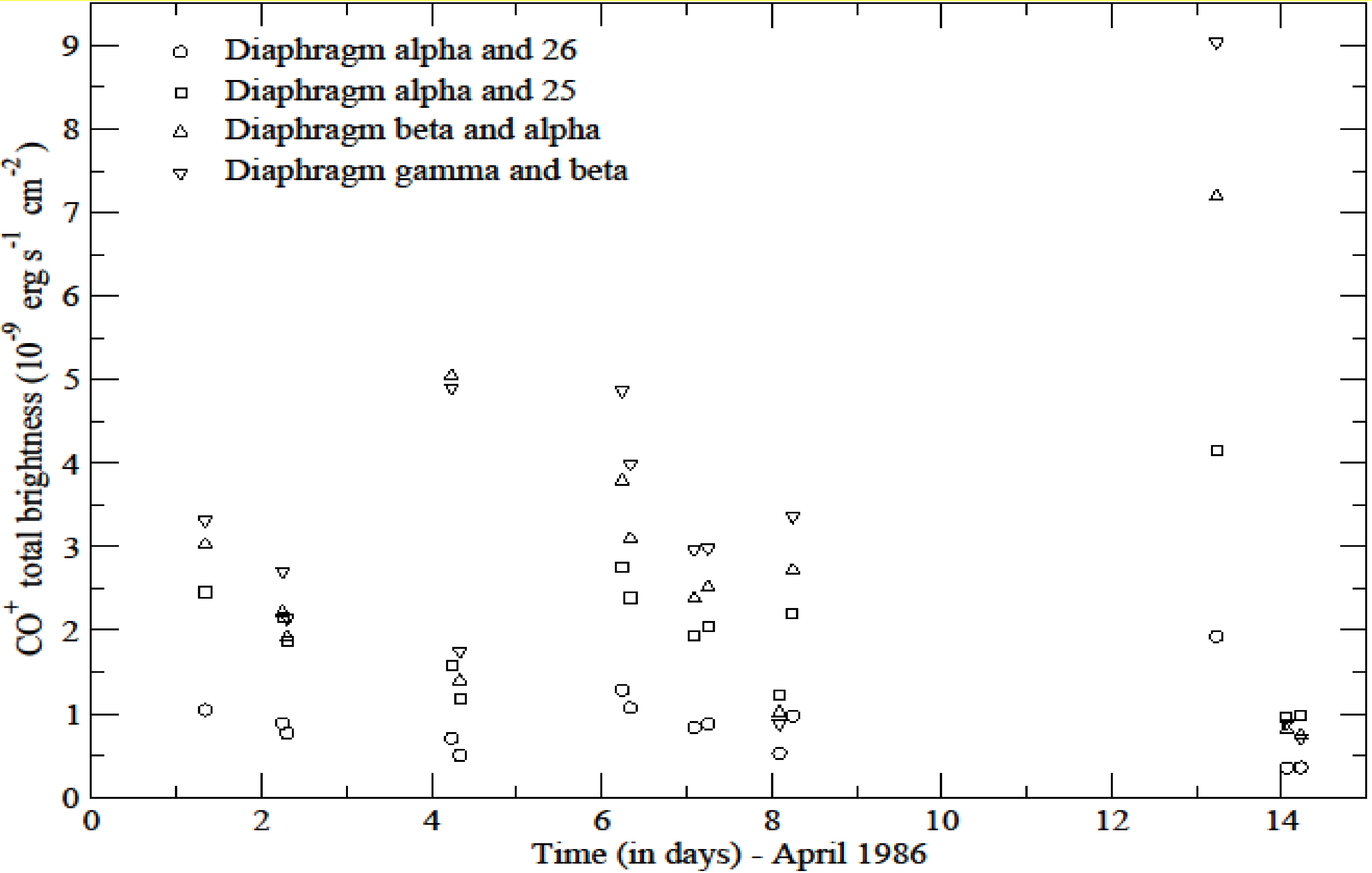


Fig. 1. CO^+ total brightness in the diaphragms alpha and 26 as well as in the diaphragms alpha and 25, in the diaphragms beta and alpha and in the diaphragms gammas and beta as time function.

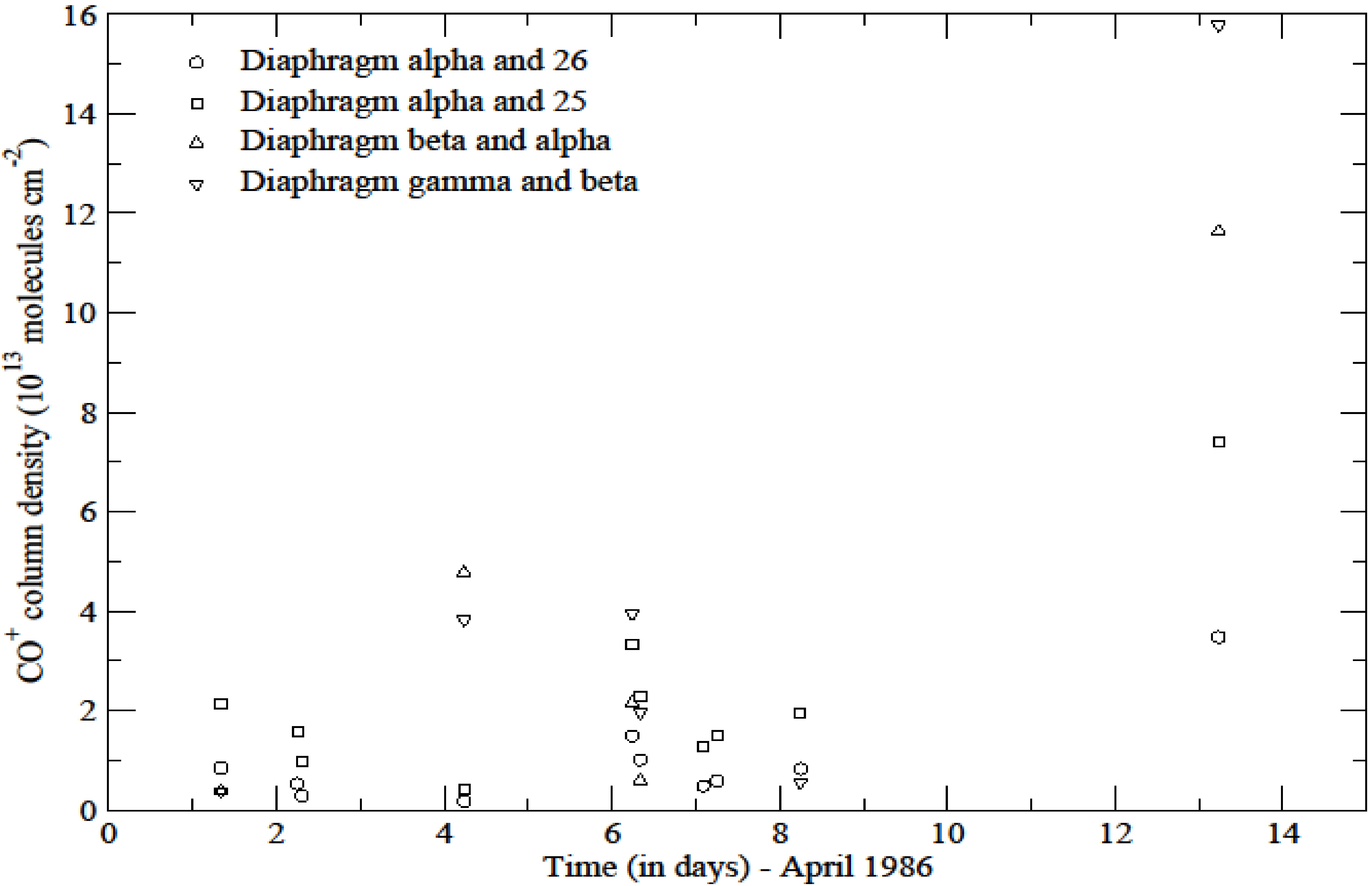


Fig. 2. CO^+ column density in the diaphragms alpha and 26 as well as in the diaphragms alpha and 25, in the diaphragms beta and alpha and in the diaphragms gamma and beta as time function.

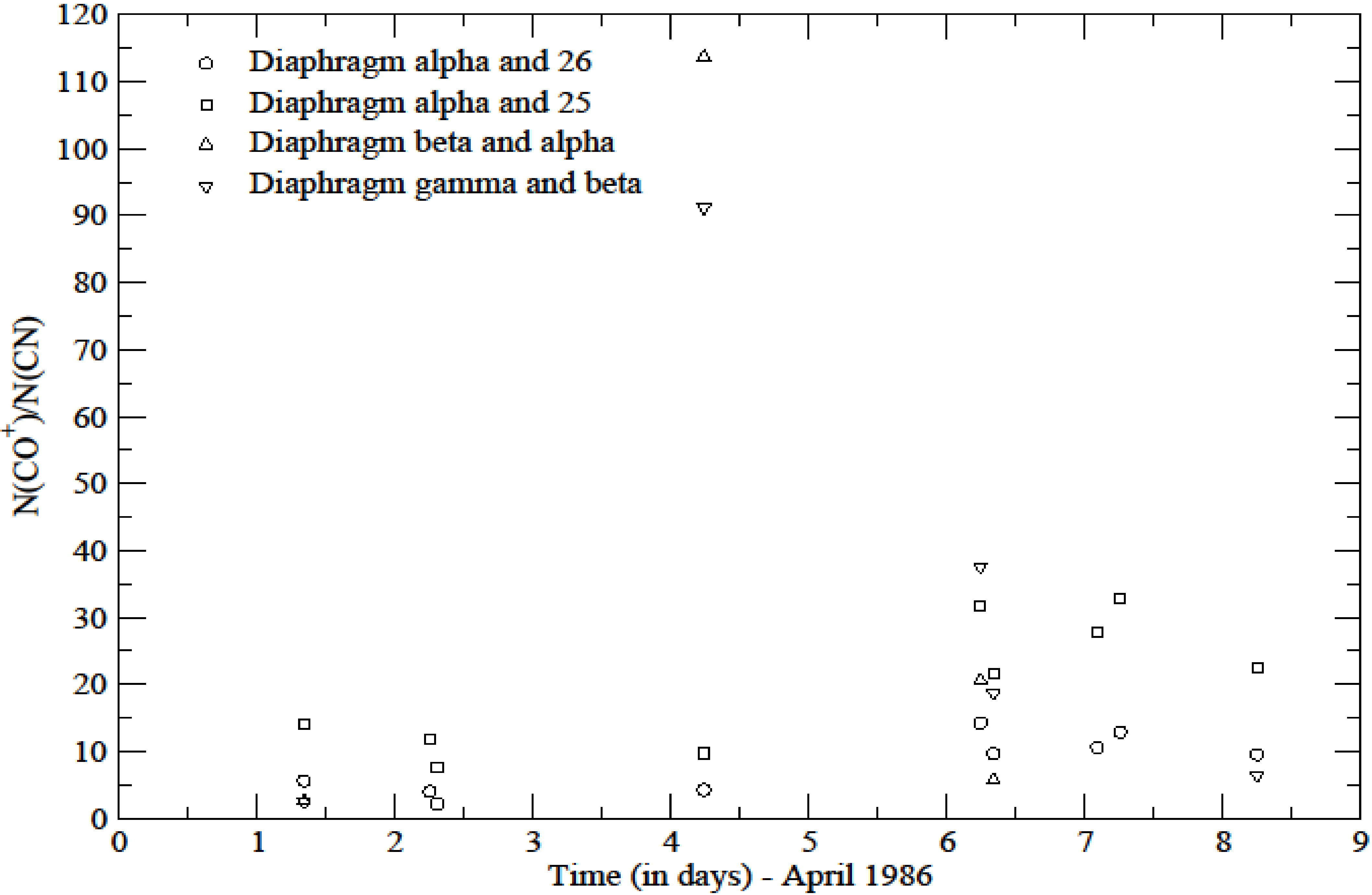


Fig. 3. N_{CO}^{+}/N_{CN} in the diaphragms alpha and 26 as well as in the diaphragms alpha and 25, in the diaphragms beta and alpha and in the diaphragms gamma and beta as time function.

Table 2. CO^+ radiation flux, CO^+ column density and proportion between CO^+ and CN column density for the diaphragms 25 and 26

Date	Picture	$F(CO^+)$ (10^{-9} erg s^{-1} cm^{-2})	$N(CO^+)$ (10^{13} molecules cm^{-2})	N_{CO+}/N_{CN}
01.04.1986	5530	0.643	1.288	8.53
02.04.1986	5546	0.507	1.040	7.88
02.04.1986	5556	0.346	0.710	5.38
04.04.1986	5602	0.106	0.229	5.45
04.04.1986	5619	-0.09	-------	-------
06.04.1986	5675	0.711	1.612	15.35
06.04.1986	5685	0.554	1.259	11.99
07.04.1986	5693	0.341	0.789	17.15
07.04.1986	5716	0.396	0.920	20.00
08.04.1986	5732	-0.071	-------	-------
08.04.1986	5751	0.471	1.121	12.88
13.04.1986	5881	1.467	3.918	-------
14.04.1986	5913	-0.156	-------	-------
14.04.1986	5949	-0.141	-------	-------

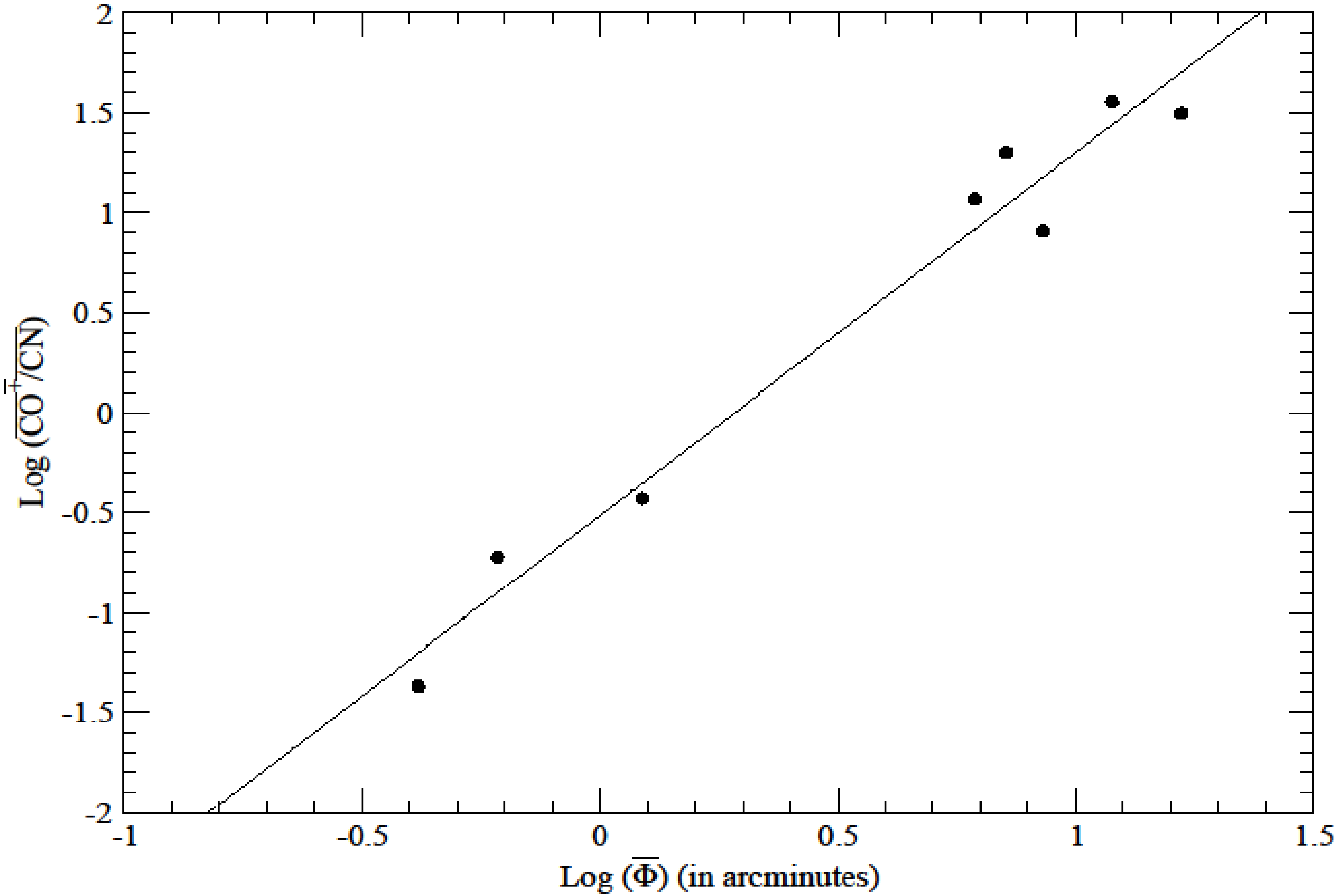


Fig. 4. N_{CO^+}/N_{CN} as a function of Phi (both in averaged values).

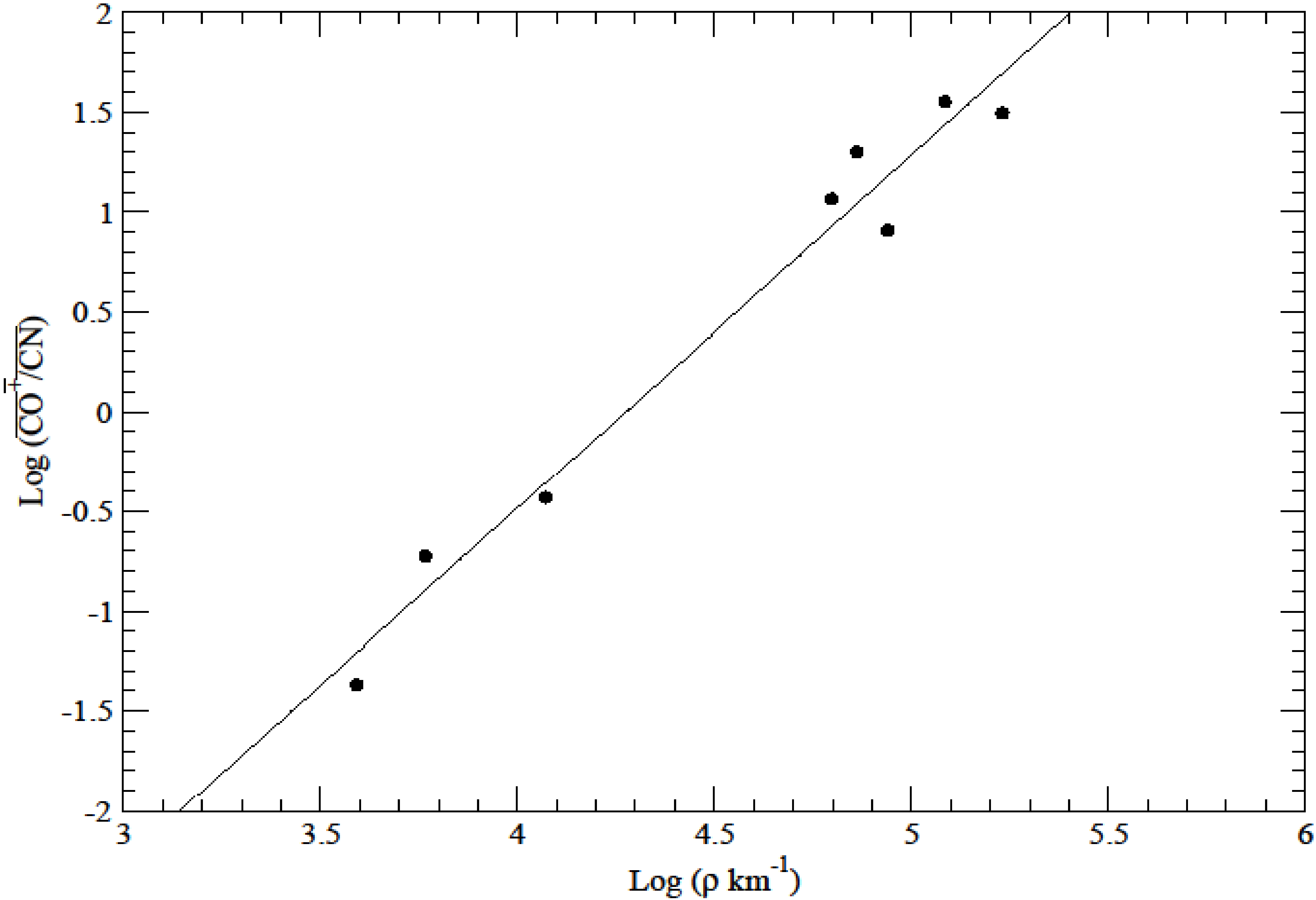


Fig. 5. N_{CO^+}/N_{CN} (in averaged values) as a function of the distance rho.

8. Conclusions

- Regarding Figs. 4 and 5 it becomes clear that the results calculated for the large diaphragms apply well to the data determined for the smaller diaphragms. This suggests that the utilised method to avoid negative values for the CO^+ radiation flux provides correct results.
- A possible explication for the increase of the curve in Fig. 5 is that the CN column density decreases the bigger the distance is, i.e., the lifetime of CN is shorter than the one of CO^+ (Schlosser et al. 1992). The CN molecule photo dissociates in C and N with a rate of 3.2×10^{-6} s^{-1} with a minimal sun activity (Huebner et al. 1992). On the other hand, the lifetime of the CO^+ ion increases along with a larger distance to the comet since the electronical recombination and also the reaction with neutral water is reduced (Häberli et al. 1995).

- The data of 1P/Halley comet make certainly a contribution to the question of resemblances and diversities of comets (for ex. Hyakutake (C/1996 B2) and Hale-Bopp (C/1995 O1)), which is of a basic interest. The optical data also help to make a connection between data measured *in situ* (observations of space crafts) and earthbound data. The data of this work give a spacious resolution (column density as function of the cometary distance) which can be compared to data of the Giotto space craft measured *in situ*, or to results of comet missions - as for example Rosetta.

References

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- Häberli, R.M., Altwegg, K., Balsinger, H., & Geiss, J., 1995, A&A 297, 881
- Huebner, W.F., Keady, J.J., & Lyon, S.P. 1992, Ap&SS 195, Number 1, 1
- Schlosser, W., et al. 1992, BAAS 24, Number 3, 1025

Muchas gracias por su atención.

Muito obrigado pela atenção dispensada.