Asteroids, Comets, Meteors 1991, pp. 81–84
Lunar and Planetary Institute, Houston, 1992

COMA IMAGING OF COMET P/BRORSEN-METCALF AT CALAR ALTO IN LATE JULY TO MID AUGUST 1989

H. Boehnhardt *(mbp Software&Systems, Dortmund, and Dr.-Remeis Sternwarte, Bamberg)*
V. Vanysek *(Charles University, Prague)*
K. Birkle *(Max-Planck-Institut für Astronomie,*
U. Hopp *Heidelberg)*

Abstract: Comet P/Brorsen-Metcalf was observed on 1989/07/28+30 and on 1989/08/04+12(+14) with the 3.5m telescope and the 0.8m Schmidt camera at Calar Alto/Spain. The images exhibit a narrow plasma tail pointing into anti-solar direction. On 1989/07/30 a triple tail was found which can be interpreted as tail ray event. The coma isophotes show prominent asymmetries with the nucleus located on the tailward side of the isophote foci and with a slightly higher brightness in the northern hemisphere of the coma. A strong curved jet feature was detected in the coma on 1989/07/30. The jet extended at least 30000 km into the sunward coma hemisphere. The rotation period of about 1.3 days, estimated from the curvature of the coma jet, needs verification by other observations.

1. Observations and Data Reduction

Comet P/Brorsen-Metcalf was observed on 1989/07/28+30 and on 1989/08/4+12(+14) from Calar Alto/Spain. The details of the 0.8m Schmidt camera and the 3.5m telescope CCD observations can be found in table 1. Standard reduction techniques were applied to the CCD frames. On the Schmidt photographic plates, the coma region and the calibration spots were digitized by means of a PDS machine. The relative calibration of the digitized exposures was performed using the intensity spots of the images. Since the isophote patterns of almost all images processed were not concentric with respect to the nucleus position, the radial renormalisation method was applied to six relative-calibrated frames. This method reduces the general coma background and enhances possible faint tail and coma structures in the images. The resulting frames are so called net images of the coma.

2. The Coma Structures

Almost all calibrated images of comet P/Brorsen-Metcalf clearly show a narrow cometary tail and an asymmetric isophote pattern in the coma. The latter phenomenon is characterized by the fact that, especialy for the outer coma isophotes, the central brightness peak in the coma is not the focus point of the isophotes, and that it is often located "tailward" of the geometric coma midpoint.

2.1 The Tail

The cometary tail is clearly visible in R while in the B filter images the tail is much fainter or even undetectable at all. It is pointing approximately into anti-solar direction of the nucleus (table 1). While on 1989/07/28 and on 1989/08/04+12(+14) the tail exhibited only a single bright ray of about 5 deg opening angle, the triple tail on 1989/07/30 (figure 1a) may indicate a cometary tail ray event. The bright central parts of the tail rays seem to be embedded in a surrounding faint parabolic shell with vertex at the nucleus position. A fan-like bright region of about 7000 km extension is located at the vertex of this tail envelope on the anti-solar side of the nucleus.
Though the dust tail was viewed nearly edge-on from Earth during the observing interval (see table 1), it might not have contributed significantly to the R-filter brightness of the tail structures because of the very low dust-to-gas production ratio in comet P/Brorsen-Metcalf (DiSanti and Fink, 1989; Roettger et al., 1989). In particular, it cannot explain the tail rays observed on 1989/07/30. Therefore, the tail phenomena described above are assumed to have been caused by the cometary plasma (the transmission of the R filter peaks near strong emission bands of H2O+).

2.2 The General Coma Structure

The net images of comet P/Brorsen-Metcalf, derived from the B and R filter CCD exposures on 1989/07/28+30 and from the B filter Schmidt plate on 1989/08/12, show enhanced relative brightness on the sunward side of the coma (figures 1a and b). This may indicate a higher activity on the sunlit part of the nucleus. Similar phenomena are known from other comets (for comet P/Halley see in Keller et al., 1987; for comet P/Tempel 2 see in Boehnhardt et al., 1989).
Furthermore, on the three observing dates mentioned above the general coma background was apparently brighter in the northern section of the sunward coma hemisphere than on the southern side. The highest deficits in the mean coma brightness were found in the southern part of the tailward coma hemisphere.

2.3 The Coma Jet

In both the B and the R filter net images of comet P/Brorsen-Metcalf on 1989/07/30 (figures 1a and b) a curved jet-like feature extended into the sunward inner coma. It originated from the nucleus at position angle of about 325 deg and turned towards the Sun during its expansion into the coma. In the B filter net image the jet can be detected above coma background to at least 30000 km projected nucleus distance. The jet and its curvature in the net images can clearly be related to the

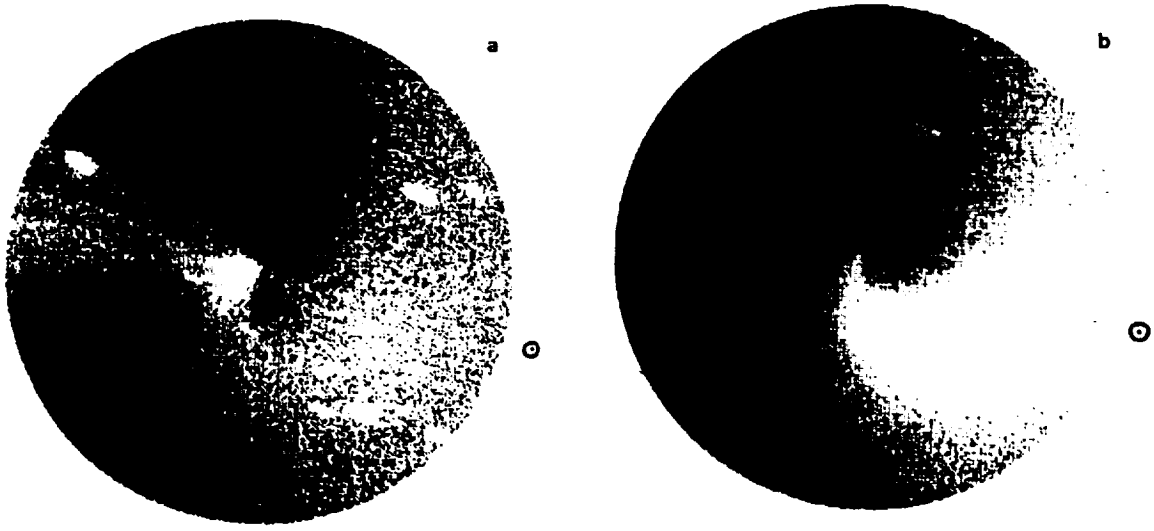
Table 1 Overview on the observations of comet P/Brorsen-Metcalf at Calar Alto Observatory/Spain (observations used for this paper)

Date (UT)	89/07/28	89/07/28	89/07/30	89/07/30	89/08/04	89/08/12
Time (UT)	3:42-3:44	3:48-3:50	3:38-3:39	3:43-3:45	2:50-3:10	4:18-4:21
Telescope	3.5m	3.5m	3.5m	3.5m	Schmidt	Schmidt
Filter	R	B	R	B	RG610	GG385
Detector	CCD	CCD	CCD	CCD	IIIaF	IIIaJ
Field of view (')	256x156	256x156	256x156	256x156	344x344*	688x688*
Pixel resolution (")	0.25	0.25	0.25	0.25	0.89	0.89
Earth distance (AU)	0.68	0.68	0.66	0.66	0.63	0.63
Sun distance (AU)	1.11	1.11	1.08	1.08	0.99	0.85
Theta (deg)	79	79	77	77	70	70
Beta (deg)	64	64	67	67	74	84
Elong (deg)	-5.5	-5.5	-3.6	-3.6	0.8	8.1
Elat (deg)	1.9	1.9	1.3	1.3	-0.3	-2.8
Psi calculated (deg)	254	254	256	256	264	280
Psi measured (deg)	253	---	240/254/259	---	265	278
Tail opening angle (deg)	5	---	5/3/6	---	5	7

Explanations:
Theta, Beta = Angles Sun-Earth-Comet, Sun-Comet-Earth
Psi = Position angle of extended comet radius vector (Zero point = North, 90 deg = East)
Elong = longitude of Earth in the cometary orbit reference frame (Zero point = Ascending node of cometary orbit)
Elat = latitude of Earth in cometary orbit reference frame (0 deg = orbital plane, 90 deg = orbit pole)
* = valid for the PDS scan of the Schmidt plate only

Figure 1 CCD exposures of comet P/Brorsen-Metcalf on 1989/07/30
North is down and East is right. The direction of the Sun is marked by symbol ⊙.
The coma brightness peak is in the centre of the field of view.

a R filter net image (60 s exposure time). Field of view: radius = 31000 km
b B filter net image (120 s exposure time). Field of view: radius = 31000 km



to at least 30000 km projected nucleus distance. The jet and its curvature in the net images can clearly be related to the asymmetric coma isophotes and their anti-clockwise change of orientation in the calibrated images.
The presence of the jet in the B and R filter exposures can be explained by reflection of solar light by the dust particles in the jet. However, the jet might have also contained a significant amount of gas which could have been produced by the dust grains in the jet (see the CN and C2 jets observed in comet P/Halley by A'Hearn et al., 1986). Similar jet features in the coma of comet P/Brorsen-Metcalf were not found in the B and R filter net images obtained on 1989/07/28 and on 1989/08/04+12.
The presence of the jet in the coma of comet P/Brorsen-Metcalf on 1989/07/30 can be interpreted as due to an isolated area of high dust and gas production on a rotating nucleus. Most likely the emission centre was active when exposed to sunlight (on 1989/07/30), since the jet emission concentrated in the sunward coma hemisphere. Apparently the jet was not or much less active during the other days when observations of the comet were obtained at Calar Alto Observatory. Because of the edge-on view of the orbital plane of the comet during the observing period one can conclude that the emission cone of the jet was intersected by the orbit plane since jet material was observed on both side of the projected extended radius vector of the comet (= tail direction). From the curvature of the jet we have estimated an approximate value of about 1.3 days for the rotation period of the nucleus (assuming the rotation axis close to the line of sight, an outflow velocity of 0.7 km/s for the jet material and neglecting possible projection effects). It compares well to the 30 to 40 hours rotation period derived by Watanabe and Nakamura (1990) from narrow band filter CCD observations of P/Brorsen-Metcalf in early August 1989. The alternative solution (13.5 to 15 hours) of these authors seems to be less likely because it implies a jet expansion velocity of more than 1.5 km/s and does not match all available jet observations. However, because of the simplifications made, our value for the rotation period has to be considered as hypothesis only unless it is confirmed by other observations of comet P/Brorsen-Metcalf.

3. References

A'Hearn, M.F. et al.: 1986, ESA SP-250 II, 207
Boehnhardt H. et al.: 1990, Icarus 86, 58
DiSanti, M.A., Fink, U.: 1989, in "Workshop on Observations of Recent Comets (1990)", eds. W. Huebner et al., San Antonio, 18
Keller, H.U. et al.: 1987, Astron. Astrophys. 187, 807
Roettger, E.E. et al.: 1989, in "Workshop on Observations of Recent Comets (1990)", eds. W. Huebner et al., San Antonio, 59
Watanabe, J., Nakamura, T.: 1990, Publ. Astro. Soc. Jap. 42, L7