ON THE DYNAMIC BEHAVIOUR OF DUST STRIAE OBSERVED IN COMETS WEST 1976VI, AND MRKOS 1957V

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ABSTRACT. The dynamic properties of the dust striae, observed in comets West 1976VI, and Mrkos 1957V, are reexamined in terms of the high speed emission model (HS model) proposed by Notni (1966). It is demonstrated that most striae can be well fitted to modified synchrones but this kind of fitting does not lead to a conclusive model; in most cases, the dynamic solution is not unique, and, furthermore, the derived high values of the ejection speed appear to be unrealistic, particularly for distant (or old) striae. The results suggest that the required initial velocity could be better interpreted as indicating the presence of nonradial acceleration.

1. INTRODUCTION

The striae observed in the dust tail of several brighter comets are an interesting topic to be reexamined on the basis of mechanical theory. This is because, on one hand, the physical interpretation of striae formation is still an unsettled problem (Sekanina 1980; Fernândez and Jockers 1983). On the other hand, the mechanical theory which involves a large number of parameters to describe the particle dynamics, has not been worked out well.

Though the possible electromagnetic nature of the dust striae has been suggested by several authors (Vsekhsvyatskii 1959, Lamy and Koutchmy 1979), quantitative dynamical analysis has so far been made only within the framework of mechanical theory. Notni (1964) suggested that the striae might be interpreted as the result of intermittent high speed ejection of particles caused by a strong coupling between the dust and high temperature plasma. The dynamical fitting appeared successful, but the difficulty to produce a hot dense plasma in a cometary environment has been pointed out (Sekanina 1980). On the other hand, Sekanina and Farrell (1980, 1982) proposed a particle fragmentation model (PF model) and carried out a detailed analysis of the dust striae observed in two comets. PF model fitting agrees with

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the observations as well, but no fragmentation mechanism is known to be consistent with the required trend of model parameters, for example, the large cometocentric distance of the fragmentation sites of the order of 10^6 km.

2. REEXAMINATION OF THE HIGH-SPEED EJECTION MODEL (HS MODEL).

An attempt was made to fit the data published by Sekanina and Farrell (1980, 1982) with an HS model calculation. Some results are shown in Figs. 1 and 2 for comets West and Mrkos, respectively. In the framework of the HS model the fitting parameters are ejection speed, v_e (or $w = v_e/V_c$, V_c denoting the orbital speed of the comet), age of the synchrone, τ (represented here as the true anomaly α_τ of the comet at the time of ejection) and azimuthal ejection angle Ψ_A. This angle is measured in the comet orbit plane from the prolonged radius vector into the direction opposite to the comet's orbital motion. For simplicity it was assumed that the vector of the ejection velocity lies in the comet orbit plane. To demonstrate the quality of

TABLE 1 Model Parameters of boxes shown in Figs. 1 and 2

Comet	Grid	True Anomaly α_τ	Ejection Velocity w	Ψ_A	γ (*)
West	W	+40°, +45°	0.30	20°, 40°	1.0, 2,5
	X	+45°, +50°	0.20	10°, 30°	"
	Y	+50°, +60°	0.10	0°, 30°	"
Mrkos	Q	+35°	0.15,0.20	0°, 20°	"
	R	+40°	0.05,0.10	0°, 20°	"
	S	+10°, 35°	0.05	0°, 20°	0.3, 0.8

(*) γ : the repulsive force in unit of solar gravity

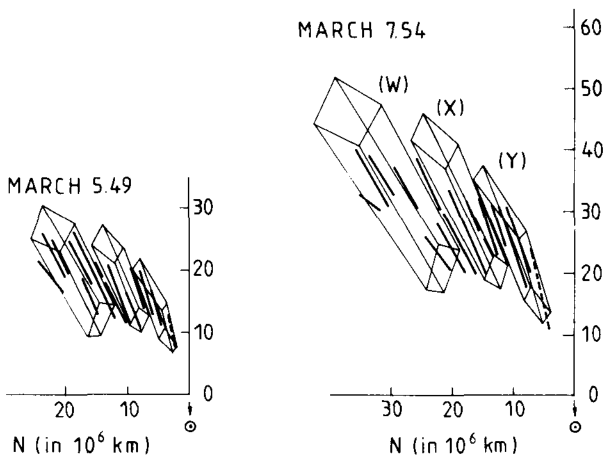

Figure 1. Time development of the striated tail of comet West 1976VI, is shown in the sky-plane projection. Observational data are taken from Sekanina and Farrell (1980). Calculated parameter boxes of displaced synchrones are superposed (for an explanation see text).

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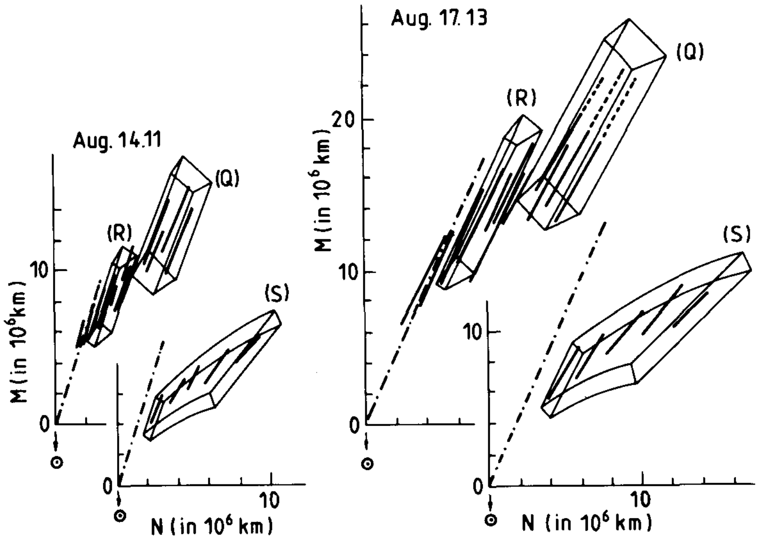

Figure 2. The same as Fig. 1 but for comet Mrkos 1957V. The obs. data are taken from Sekanina and Farrell (1982). The bottom graphs refer to the second family of striae observed in this comet.

the fit, in Figs. 1 and 2 in addition to the observed striae (heavy lines) "parameter boxes" are shown, of which the parameters are listed in Table 1.

While the overall fit seems quite satisfactory it is worth noting that in case of comet West the required ejection speed and angle gradually increase with increasing age of the stria (Y → X → W). This may indicate, that, contrary to our assumption, the ejection direction is not restricted to the comet orbit plane. During the relevant period of observations, the angle between line of sight and comet orbit plane was 35° for comet West in contrast to 65° for comet Mrkos.

In Fig. 3 the speed of particle ejection required to fit the striae in comets West and Mrkos is plotted vs heliocentric distance of the comet. For comparison, the orbital velocity of the comets are also shown.

3. DISCUSSION AND CONCLUSION

In comparison with the PF model of Sekanina and Farrell (1980, 1982) the following results emerge from this study: (A) Both the PF and HS model require high values of the repulsive force parameter γ (Table 1), i.e., absorbing submicron particles (0.1 - 0.3 μm in radius) as the main component of striae. (B) In both models the derived initial conditions are physically unrealistic, the too large ejection speed in the HS model as well as the too large cometocentric distance of the fragmentation site in the PF model. (C) The derived parameters for the striae show a remarkably large systematic variation with increasing age (see Figs. 3 and 4).

According to the current idea on the electrostatic charging of

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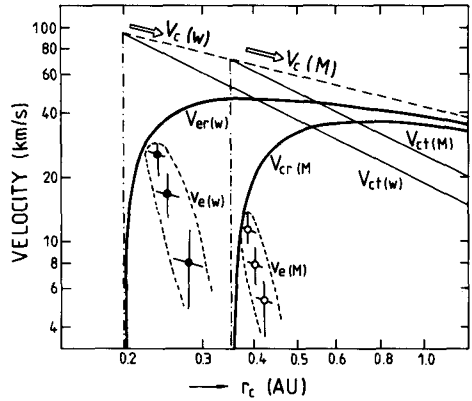

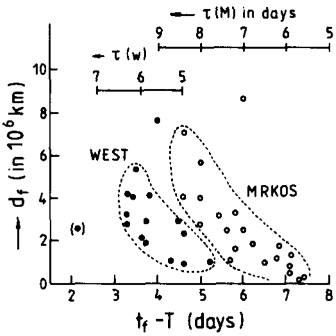

Figure 3. (left) The ejection speed v_e of the particles required for striae formation is plotted vs heliocentric distance of the comet. The magnitude V_c and the radial and transverse components V_{cr} and V_{ct} of the orbital velocity of the two comets are also shown. Subscripts M and W refer to comets Mrkos and West,respectively.

Figure 4. (right) The cometocentric distance of fragmentation, as required in the PF model is plotted as a function of time relative to perihelion passage (adapted from Sekanina and Farrell 1980, 1982).

dust grains, the submicron size particles in interplanetary space are very likely to be affected by Lorentz force acceleration (Wallis and Hassan 1983). From this viewpoint, statements (A) and (B) indicate the invalidity of models based solely on the central forces of the inverse square law (mechanical theory). Furthermore, statements (A) and (C) suggest the presence of nonradial acceleration; the magnitude of this acceleration may be roughly estimated as the ratio of v_e/τ obtained in the HS model. This value amounts to about 0.3 g_o in the case of comet West, and to about 0.5 g_o for comet Mrkos, where g_o denotes the solar gravitational attraction. These values are in the reasonable range of Lorentz-force acceleration acting on charged dust particles (Ip, Kimura and Liu in this volume).

REFERENCES

Fernãndez, J.A., and Jockers, K. (1983) Rep. Progr. Phys. 46, 665
Ip, W.-H., Kimura, H., and Liu, C.-P. (1985) this volume.
Lamy, P., and Koutchmy, S. (1979) Astron. Astrophys. 72, 50
Notni, P. (1964) Veröff. Sternw. Babelsberg, 15, No. 1, p. 1
Sekanina, Z. (1980) in "Solid Particles in the Solar System, IAU Symp. No. 90", ed. by I. Halliday and B.A. McIntosch, p. 237
Sekanina, Z., and Farrell, J.A. (1980) Astron. J. 85, 1538
Sekanina, Z., and Farrell, J.A. (1982) Astron. J. 87, 1836
Vsekhsvyatskii, S.K. (1959) Sov. Astron. J. 3, 490
Wallis, M.K., and Hassan, M.H.A. (1983) Astron. Astrophys., 121, 10

https://doi.org/10.1017/S0252921100084803 Published online by Cambridge University Press