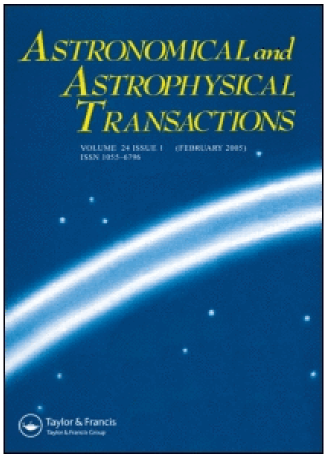

Astronomical & Astrophysical Transactions
The Journal of the Eurasian Astronomical Society
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713453505

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To cite this Article: Ibadov, S. (1999) 'Coronal radiation from the Sun and comets', Astronomical & Astrophysical Transactions, 18:1, 261 - 263
To link to this article: DOI: 10.1080/10556799908203064
URL: http://dx.doi.org/10.1080/10556799908203064

Astronomical and Astrophysical Transactions, 1999,
Vol. 18, pp. 261–263
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CORONAL RADIATION FROM THE SUN AND COMETS[†]

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(Received October 18, 1996)

Comparison of characteristics of X-ray radiation from the solar corona plasma and proper radiation from the cometary collisional plasma shows that an observable X-ray radiation from dusty comets may appear in the range of heliocentric distances of comets $R \leq 0.5$–1 AU owing to production of cometary collisional hot plasma from impacts of cometary and zodiacal dust particles. On this basis an explanation of X-rays from comet Hyakutake detected by ROSAT is proposed.

KEY WORDS Solar corona, high-temperature plasma, cometary collisional plasma, X-ray radiation

1 INTRODUCTION

The solution of the coronal lines problem and the discovery of the presence of a high-temperature phase in the solar atmosphere is discussed in the light of the work of Prof. I. S. Shklovsky and Prof. S. B. Pikelner.

The possibility of generation of a high-temperature phase in the macroscopically cold atmospheres of comets due to collisional interaction of cometary and zodiacal dust clouds near the Sun is analysed.

2 COMPARISON OF CORONAL RADIATION FROM THE SUN AND COMETS

The emission lines $\lambda\lambda$ 3987, 4087, 5303, 5694, 6374, 6202 and others of the solar corona, the lines of the hypothetical element "coronius", which existed for 70 years (1869–1939), were in reality emissions of such heavy multielectron elements as Ca, Fe, Ni, etc., being in a special physical state, namely highly-ionized. This discovery, the solution of the coronal lines problem, along with the detection of the intense

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[†] Paper presented at the International Conference "Current Problems in Astrophysics" (Sternberg Astronomical Institute, Moscow, September 23–28, 1996)

soft X-ray radiation from the quiet Sun ($\simeq 0.1$ erg cm^{-2} s with $h\nu_{\max} \simeq 100$ eV near the Earth's orbit), indicated the existence in the atmosphere of the Sun and stars of a high-temperature phase.

The temperature of this phase, the coronal temperature of "point" objects, may be presented as

$$T_* = T_\odot \frac{M}{R}, \tag{1}$$

where $T_\odot$ is the temperature of the solar corona, and M and R are the mass and radius of a star expressed in "solar" units (Shklovsky, 1951; 1962).

The dissipation of protons, as solar and stellar winds, is the "thermostating" effect resulting in the constancy of the kinetic temperature of the mainly electron–proton coronal plasma at a level of $T_\odot \simeq 1.5 \times 10^6$ K.

The temperature of the corona corresponds, as shown by Pikelner (1950; 1966), to the parabolic velocity of protons of the coronal plasma.

Analysis shows that there is another possibility of production of a high-temperature plasma near the Sun, namely the generation of a hot plasma is possible in the atmospheres of comets passing through the solar corona due to impacts between cometary and zodiacal dust particles with high relative velocities, V. Indeed, the initial temperature of the expanding plasma blobs produced is determined by

$$T = T_1 \frac{V^2}{V_1^2} = T_1 \frac{R_1}{R_c}, \tag{2}$$

where $T_1 = 3 \times 10^5$ K is the value of T at $V = V_1 = 7 \times 10^6$ cm s^{-1} and $R_c = R_1 = 1$ AU; R_c is the heliocentric distance of the comet.

The maximal initial temperature of the cometary collisional plasma reached, according to (2), at the inner boundary of the zodiacal dust cloud is $T_{\max} = T(R_c \simeq 0.01 \text{ AU}) \simeq 3 \times 10^7$ K.

Thus, in the range of heliocentric distances of comets, $R_c = 0.01$–0.1 AU, the maximum of the spectrum of emission of the plasma produced by collisions of cometary and zodiacal dust particles is located in the harder region of the spectrum than the coronal X-ray emission of the quiet Sun (Ibadov, 1983).

The intensity of the proper radiation of the cometary head due to production of the collisional plasma is equal to

$$J_x = \frac{L_x}{4\pi r_{\text{cd}}^2} \simeq \frac{L_{x1}}{4\pi r_{\text{cd}}^2 R_c^7}, \tag{3}$$

where L_x is the X-ray luminosity of the comet connected with the generation of the hot plasma in the way considered above, r_{cd} is the comet–detector distance, and L_{x1} is the value of L_x at $R_c = 1$ AU.

For dusty comets like Halley 1986 III we have $L_{x1} = 10^{12}$ erg s^{-1}, so that at $r_{\text{cd}} = 0.1$ AU $= 1.5 \times 10^{12}$ cm according to (3) we get $J_x = 4 \times 10^{-14}$ erg cm s^{-1} for photons with $h\nu \geq 50$ eV.

At the same time the value of J_x obtained essentially exceeds the expected value of the cometary X-ray flux produced by classical resonance fluorescent mechanisms, i.e. by scattering of the solar X-ray radiation on cometary matter (Ibadov, 1985).

These data indicate the possibility of detection of X-rays from certain dusty comets by modern space telescopes such as ROSAT and XMM (Ibadov, 1990; 1995).

It is interesting to note that on March 27, 1996, ROSAT detected X-rays from comet Hyakutake at $R_c \simeq 1$ AU and $r_{\text{cd}} \simeq 0.1$ AU (Lisse *et al.*, 1996).

3 CONCLUSION

Both theoretical and observational data indicate that dusty comets near the Sun generate corona-like hot matter and become active objects of high energy astrophysics. Such comets can serve as probes for studying the distribution of interplanetary and circumsolar dust.

Acknowledgements

The author is grateful to the Organizing Committee of the International Conference "Current Problems in Astrophysics", devoted to the memory of Profs I. S. Shklovsky, S. B. Pikelner and S. A. Kaplan (Sternberg Astronomical Institute, Moscow State Lomonosov University, 23–28 September 1996), for an invitation and travel grant.

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