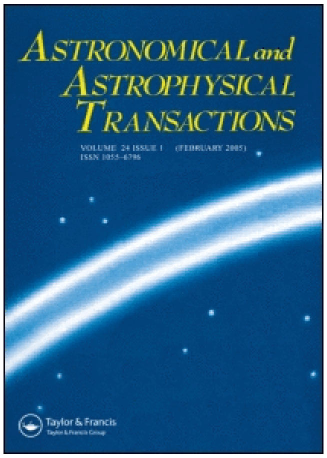


Astronomical & Astrophysical Transactions
The Journal of the Eurasian Astronomical Society
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713453505

# Brightness of calcium emission regions associated with the solid material sublimation in the near circumsolar space

Gulyaev; Petrov

Online Publication Date: 01 January 2003
To cite this Article: Gulyaev and Petrov (2003) 'Brightness of calcium emission regions associated with the solid material sublimation in the near circumsolar space', Astronomical & Astrophysical Transactions, 22:4, 617 - 620
To link to this article: DOI: 10.1080/1055679031000139451
URL: http://dx.doi.org/10.1080/1055679031000139451

Astronomical and Astrophysical Transactions
Vol. 22, Nos. 4–5, August–October 2003, pp. 617–620





# BRIGHTNESS OF CALCIUM EMISSION REGIONS ASSOCIATED WITH THE SOLID MATERIAL SUBLIMATION IN THE NEAR CIRCUMSOLAR SPACE

R. A. GULYAEV[a,]* and N. I. PETROV[b]

[a]IZMIRAN, 142190 Troitsk, Moscow Region, Russia;
[b]Institute of Astronomy, Bulgarian Academy of Sciences, Sofia

(Received July 30, 2002)

Photometric reduction of the Ca II K-line interferogram obtained during the total solar eclipse on February 26, 1998, has been carried out. The interferogram covering the circumsolar region of the sky includes K-line emission features due to the solid material sublimation close to the Sun. The number of emitting Ca II ions and the total mass of sublimated material are estimated. Results of such investigations should be significant for cosmogonical research.

Keywords: Solar corona; Interplanetary medium; Solar eclipses

## 1 INTRODUCTION

During the total solar eclipse on February 26, 1998, Gulyaev and Shcheglov (1999a) have registered for the first time the resonance emission of the calcium ions released by the solid material sublimation close to the Sun (see also the paper by Gulyaev (2003) in this issue). To search for Ca II K emission in the sky around the Sun, the interferometric technique has been employed. Previously a morphological analysis of the interferogram obtained has been carried out (Gulyaev and Shcheglov, 1999b, 2001). The most important result of this analysis is the following: calcium resonance emission is not distributed regularly around the Sun. Instead, it is located in separate compact regions. Such discrete sporadic formations may be associated with streams of stones and dust (e.g. meteoroid streams or Sun-grazing comets) sublimating in the near circumsolar space (Shestakova, 1999).

Recently we have made a photometric analysis of the above interferogram. We intended to obtain a rough estimate (say, to within an order of magnitude) of the surface brightness of the calcium emission regions. Some results of the photometric analysis are presented in the following sections.

* Corresponding author. E-mail: rgulyaev@izmiran.troitsk.ru

ISSN 1055-6796 print; ISSN 1476-3540 online 
DOI: 10.1080/1055679031000139451

## 2 PHOTOMETRIC ANALYSIS OF THE 1998 ECLIPSE INTERFEROGRAM

The locations of three calcium emission regions observed on February 26, 1998, are shown in Figure 1. The emission under discussion inside the regions outlined is manifested as fragments of interference rings consistent with the Ca II K line shifted by the Doppler effect by 2.2–3.7 Å (line-of-sight velocities of 170–280 $km\,s^{-1}$) (Gulyaev and Shcheglov, 2001). One of these emission features inside region 1 was selected for detailed photometric analysis. The centre of this feature is located at a distance of $11.5R_{Sun}$ from the Sun.

Relative photometric reduction of the interferogram has been made in the traditional way with a Joyce–Loeble microdensitometer at the Rozhen Observatory of the Bulgarian Academy of Sciences. Our negative includes the image of Mercury which can serve as an absolute photometric standard. Earlier we developed a special method of absolute calibration of interferograms using point emission sources. A suitable procedure has been described

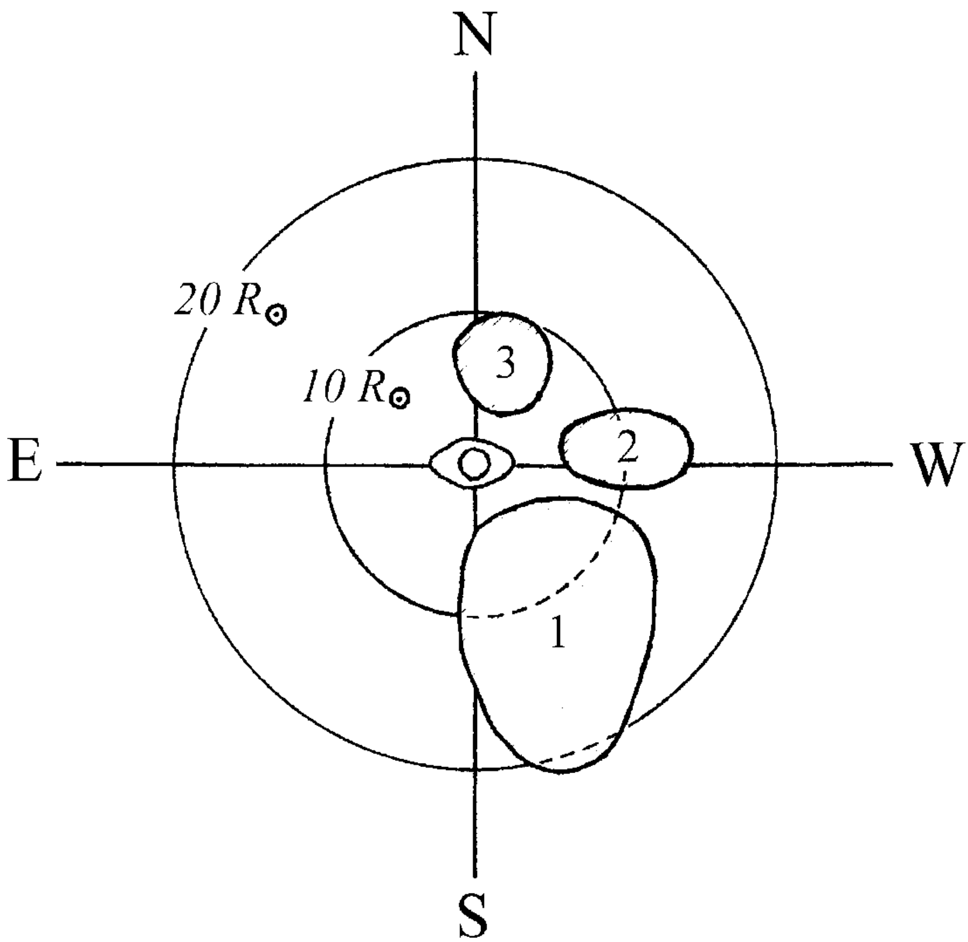


FIGURE 1 Locations of three regions of the Doppler-shifted K-line emission with respect to the Sun on February 26, 1998. Symbolic images of the Sun and the solar corona are shown in the centre of figure. NS is the projection of the Sun's rotation axis on the plane of the sky. Two concentric circles correspond to heliocentric distances of $10R_{Sun}$ and $20R_{Sun}$.

in detail by Gulyaev et al. (2002). So, we present here only the final results of calculations. The surface brightness of the calcium emission region was found to be equal to

$$I_{obs}^{(1)} = 2.2 \times 10^{-5} \text{ erg cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1}.$$

One can also estimate the brightness desired by comparison with the eclipsed sky intensity. According to a private communication by S. Koutchmy, the brightness of the sky during the totality of 1998 was equal to $2 \times 10^{-9}$ of the solar disc centre intensity. The brightness of selected emission feature on the interferogram is equal to 0.16 of the background intensity. Hence it follows that

$$I_{obs}^{(2)} = 12 \times 10^{-5} \text{ erg cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1}.$$

The ratio of the surface brightness values obtained in two independent ways is about 5. This indicates sufficient reliability of the absolute calibration in our specific case. The values of ${I_{obs}}^{(1)}$ and ${I_{obs}}^{(2)}$ can be taken as the lower and the upper boundaries respectively. The mean of the above limits can be thought of as the characteristic value of brightness of emission features in the K line:

$$I_{obs} = 7 \times 10^{-5} \text{ erg cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1}. \quad (1)$$

## 3 ESTIMATE OF THE TOTAL MASS OF SUBLIMATION PRODUCTS

The mechanism of the K-line emission near the Sun involves resonance scattering of solar radiation. As a result of the required calculations taking into account the profile of the Fraunhofer K line, the solar radiation dilution at suitable heliocentric distances and other necessary parameters, we obtain the following:

$$I_{theor} = 0.85 \times 10^{-10} \text{ N erg cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1}, \quad (2)$$

where N is the column density of the Ca II ions along the line of sight. It follows from equations (1) and (2) that

$$N(\text{Ca II}) = 8 \times 10^{5} \text{ cm}^{-2}.$$

It is believed that the whole of the calcium in the sublimation regions observed exists in the Ca II state. To estimate the total number $\bar{N}(\text{Ca})$ of calcium atoms we multiply the value N(Ca II) by the area of projection of the emission region on the plane of sky. For the region 1, we obtain $\bar{N}(\text{Ca}) = 3.6 \times 10^{29}$. As the mass of the calcium atom is equal to $66 \times 10^{-22}$ g (Allen, 1973), the total mass M(Ca) of calcium is obtained as equal to $2.4 \times 10^{7}$ g. Similar calculations for the regions 2 and 3 yield value of $0.6 \times 10^{7}$ g. Accurate to within one order of magnitude, we can take the value of $10^{7}$ g or 10 tons as representative of the M(Ca) quantity.

Let us assume that the mass content of calcium in the sublimating solid material is equal to 1% as in the case of some chondrites (see for example Brandt and Hodge (1964)). Then the total mass of sublimation products in a separate region is equal to about $10^{9}$ g or 1000 tons. Finally, if we consider the sublimating parent body as an individual stone of density of $5 \text{ g cm}^{-3}$, then the diameter of such a body will be equal to about 6 m.

## 4 CONCLUSION

The study of the dynamics and evolution of the solid material penetrating into the near circumsolar space is significant in terms of cosmogony. This is essential in particular, for understanding processes occurring in young protoplanetary systems discovered around some stars, for example β Pictoris. Our technique for investigation of the evolution of the sublimation products by resonance emissions of atoms and low-charged ions appears to be very promising. Extension of observations to resonance lines of other elements together with calcium is extremely important.

## References

Allen, C. W. (1973). Astrophysical Quantities. Athlone Press, London.

Brandt, J. C. and Hodge, P. W. (1964). Solar System Astrophysics. McGraw-Hill, New York.

Gulyaev, R. A. (2003). Russian–Bulgarian collaboration Astron. Astrophys. Trans. (accepted for publication).

Gulyaev, R. A. and Shcheglov, P. V. (1999a). Dokl. Akad. Nauk, 366, 199.

Gulyaev, R. A. and Shcheglov, P. V. (1999b). Contrib. Astron. Observ. Skalnate Pleso, 28, 237.

Gulyaev, R. A. and Shcheglov, P. V. (2001). Usp. Fiz. Nauk, 171, 217.

Gulyaev, R., Dermendjiev, V., Gavrilov, M., Dechev, M., Petrov, N. and Shcheglov, P. (2002). In: Mishev, D. N. and Phillips, K. J. H. (Eds.), First Results of 1999 Total Eclipse Observations. Professor Martin Drinov Academic Publishing House, Sofia, pp. 69–76.

Shestakova, L. I. (1999). In: Filippov, B. P. (Ed.), Structure and Dynamics of Solar Corona. IZMIRAN, Troitsk, pp. 179–186.