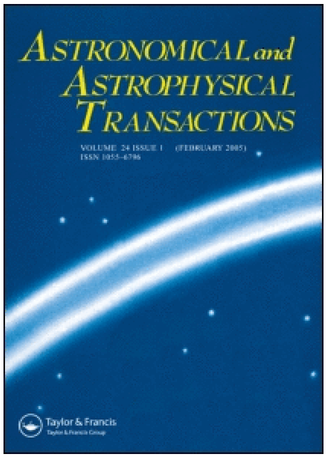

Astronomical & Astrophysical Transactions
The Journal of the Eurasian Astronomical Society
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713453505

A new interpretation of Orion gamma-rays and the 26-Al problem

E. Y. Vilkoviskij [a]
[a] Fesenkov Astrophysical Institute of NAS, Almaty 68, Kazakstan

Online Publication Date: 01 August 1999
To cite this Article: Vilkoviskij, E. Y. (1999) 'A new interpretation of Orion gamma-rays and the 26-Al problem', Astronomical & Astrophysical Transactions, 18:1, 159 - 162
To link to this article: DOI: 10.1080/10556799908203050
URL: http://dx.doi.org/10.1080/10556799908203050

Astronomical and Astrophysical Transactions, 1999, Vol. 18, pp. 159–162
Reprints available directly from the publisher
Photocopying permitted by license only

Stars and γ-Bursters

A NEW INTERPRETATION OF ORION GAMMA-RAYS AND THE 26-Al PROBLEM

E. Y. VILKOVISKIJ

Fesenkov Astrophysical Institute of NAS, 480068, Almaty 68, Kazakstan

(Received September 27, 1996)

We consider a new theory of gamma radiation from O-B-star stellar winds and support it by comparison with the COMPTEL data on the Orion gamma radiation.

KEY WORDS Stellar wind: theory, gamma rays: theory

The kinetic processes of runaway ions due to radiation-pressure forces in O-B stellar winds have been concidered Vilkoviskij (1981) for the case of a steady continuous plasma flow. Later more detailed analysis have shown (Vilkoviskij, 1994, hereafter P1) that gamma radiation can arise from the interaction of accelerated ions with the background stellar-wind particles. During the past few years, the paradigm of the "steady" and "cold" winds has been rejected with the observations of variations in the UV lines; theoretical instability analysis (Owocki and Rybicki, 1984) and, most of all, by the evidence of strong shock waves deep in the wind from the analysis of X-ray spectra.

It is very important that structure *favours* the runaway acceleration of ions in the intershock (low-density) media because the friction force (which is proportional to the density) drops and the Sobolev absorption depth diminishes due to both the growth of the velocity gradient and the fall in density. In these circumstances, the physics of ion acceleration turn out to be very simple and we can use the "low-optical-depth" case (for more details see P1).

We considered the acceleration of ions of the most abundant elements with strong resonance lines C IV, O VI, Si IV and Al III. We chose the following parameters for a model star and its wind: the radius and the effective temperature of the star are $R_* = 10^{12}$ cm and $T_* = 3 \times 10^4$ K; the mass-loss rate is $\dot{M} = 10^{-6} M_\odot$ year^{-1}, and the terminal velocity of the wind is $V = 2 \times 10^3$ km s^{-1}. The parameters are close to the model of Puls *et al.* (1993).

As soon as runaway conditions are fulfilled for these ions, they are accelerated independently of the rest of the wind, until they no longer change the ionization stage, since the neighbouring stages do not have strong resonant lines. Then the

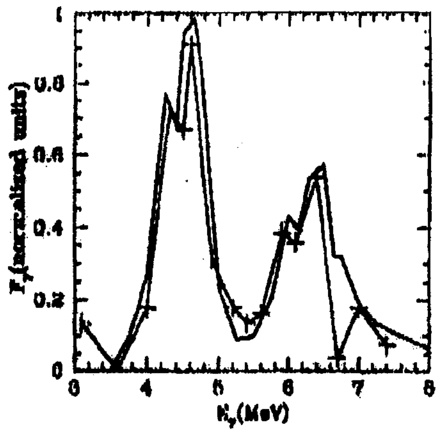

Figure 1 Theoretical normalized gamma-ray spectrum compared to the COMPTEL data (crosses).

number of ions depends on the "penetration depth"

$$p_i = \int_0^l n_c Q_i \, dl$$

(where Q_i is the electronic ionization cross-section and l is the distance of the ion run) as

$$n_i = n_{i0} \exp(-p_i),$$

and the energetic spectrum of the ions can be defined as

$$n_i(E) = \frac{d}{dp_i}(1 - n_i)\frac{dp_i}{dE}.$$

Taking into account $l(E) = E/m_i a$, where E and a are the kinetic energy and the acceleration of the ion and m_i is the ion's mass, we have calculated the spectra of the ions.

The accelerated ions penetrate into shock fronts, lose their energy and generate gamma rays by nuclear reactions on the He nuclei and protons. We use the "modified thin target" model for the nuclear reaction calculations, and take into account the repeated acceleration of ions N times between supposed N shocks ($N = 10$). Here we use the simplest "soft" modification variant: we multiply the distribution function by Nv_i/c (the ion velocity divided by the velocity of light).

Using nuclear cross-sections from Ramaty *et al.* (1979), we have calculated the gamma-ray spectrum of this model star in the (3–7) MeV band. The spectrum is shown in Figure 1 together with the observed COMPTEL spectrum (crosses). As one can see, the calculated spectrum agrees with the observed one in *nearly every detail.*

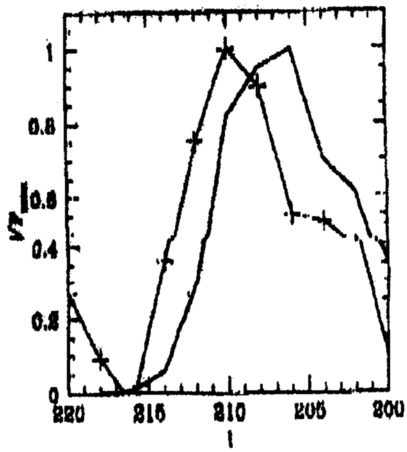

Figure 2 The gamma-ray flow distribution along the l-cut. Crosses represent the COMPTEL data.

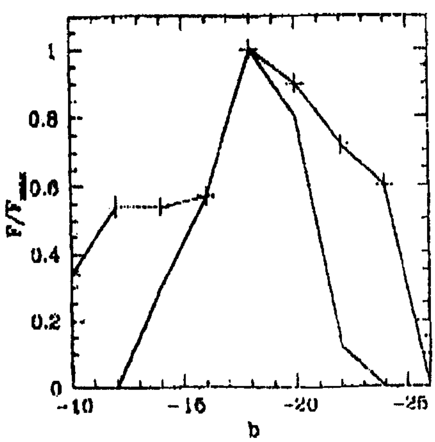

Figure 3 The gamma-ray flow distribution along the b-cut. Crosses represent the COMPTEL data.

In Bloemen *et al.* (1994) the distribution of the γ-radiation flow as cuts with a circle of 3° radius are presented, one in the longitude and one in the latitude direction, both going through the point with coordinates latitude $b = -18°$ and longitude $l = 208°$. To support the hypothesis that most of the observed gamma radiation is generated by stellar winds of O-B stars, we have compiled a list of the O-B stars seen in the Orion complex COMPTEL observed field and calculated the distribution of their gamma radiation along these cuts. The list of stars includes 142 O-B stars with spectral classes earlier than B4.

The calculated cuts are shown in Figures 2 and 3 together with the observed ones (crosses). One can see that the observed and calculated flows through the cuts are in satisfactory agreement. Some inconsistences were expected due to the strong absorption of the stars' optical radiation by the dust clouds in the Orion complex.

More detailed observations of the Orion complex with COMPTEL, as well as observations from single O-B stars are desirable.

If these observations confirm the stellar-wind origin of Orion gamma radiation, then nuclear reaction in the winds are essential for the production of the 26-Al isotope (by accelerated Si IV and Al III ions) and for the production of other elements as well.

References

Bloemen, H. *et al.* (1994) *Astr. Astrophys.* **281**, L5.
Owocki, S. P. and Rybicki, G. B. (1984) *Astrophys. J.* **284**, 337.
Puls, J., Owocki, S. P., and Fullerton, A. (1993) *Astr. Astrophys.* **279**, 457.
Ramaty, R., Kozlovsky, B., and Lingenfelter, R. (1979) *Astrophys. J. Suppl.* **40**, 487.
Vilkoviskij, E. (1981) *Astrophys.* **17**, 310.
Vilkoviskij, E. (1994) *Astr. and Astrophys. Transact.* **5**, 279.