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GAMMA-RAY EMISSION FROM MASSIVE YOUNG STELLAR OBJECTS: THE CASE OF IRAS 16547-4247

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The young stellar object IRAS 16547-4247, identified with a massive protostar, presents a highly collimated wind which interacts with the environments. As a result, strong shocks are formed at the jet termination point and particles are accelerated there up to relativistic energies. In the present contribution, the high-energy emission due to non-thermal interactions is calculated.

IRAS 16547 − 4247 is a very luminous ($L = 6.2 \times 10^4\ L_\odot$) IR source associated with a star-forming region, located at a distance of 2.9 kpc. Garay et al. (2003) reported the radio detection of a young stellar object (YSO) embedded in the giant molecular cloud ($\sim 10^3\ M_\odot$) that generates the IR flux. The radio source presents a triple linear structure composed by two lobes symmetrically separated from a central thermal source. Observations made with ATCA and VLA (Rodríguez et al. 2005) indicate that the Southern lobe has a clear non-thermal spectrum, with an index $\alpha = -0.59$ ($S_\nu \propto \nu^\alpha$). The non-thermal emission is interpreted as synchrotron radiation produced by relativistic electrons accelerated at the termination shock of the thermal jet. Since these electrons move in a dense medium with a high density of IR photons, Bremsstrahlung and inverse Compton (IC) losses are unavoidable. Protons are expected to be accelerated as well and can interact with the cold material. The maximum energy achieved can be obtained by equating the cooling and acceleration rates.

The average matter density of the cloud is 5.2×10^5 cm^{-3} and the energy density of IR photons in the cloud, assuming an homogeneous distribution, is $w_{\rm ph} \approx 1.8 \times 10^{-9}$ erg cm^{-3}. The magnetic field was determined from the equipartition condition.

The relativistic proton energy density in the source is related to the primary electron energy density by $u_{\rm p} = a u_{\rm e_1}$. Three cases were considered: (1) there is no proton acceleration ($a = 0$), (2) there is the same energy density in protons as in electrons ($a = 1$), and (3) protons are energetically dominant ($a = 100$). In the calculations for $a = 1$ and $a = 100$ the contribution from secondary leptons originated in charged pion decays were taken into account.

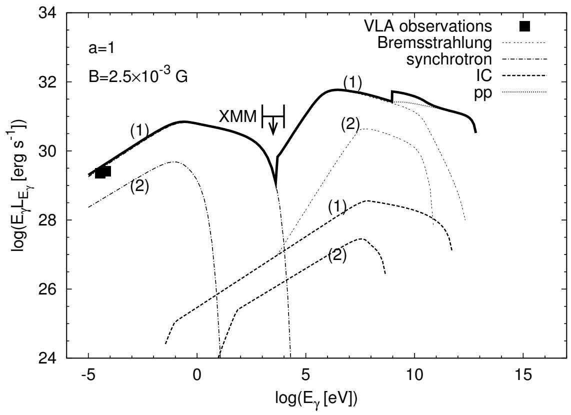

Fig. 1. Spectral energy distribution. We indicate with numbers (1) and (2) the contribution from primary and secondary electrons, respectively.

From the SED shown in Figure 1, it can be seen that relativistic Bremsstrahlung is very important at soft X-ray energies, with luminosities in the range $10^{30} - 10^{31}$ erg s^{-1}. Such emission could be detectable by Chandra and XMM satellites. The Bremsstrahlung extends up to GeV energies, with γ-ray luminosities that are close to 10^{32} erg s^{-1}, making possible the observation of the source by the forthcoming LAT instrument of the GLAST orbital observatory. TeV energies are possible only in the cases where protons can be effectively accelerated ($a = 1$ and $a = 100$) and the γ-ray emission is then due to neutral pion decay. Luminosities of $\sim 10^{32}$ erg s^{-1}, in the case $a = 100$, are possible. The associated flux might be detactable by future Cherenkov arrays like HESS II or other planned high-sensitivity instruments.

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