RevMexAA (Serie de Conferencias), **40**, 151–152 (2011)

CAN T TAURI STARS PRODUCE HIGH-ENERGY RADIATION?

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RESUMEN

Las estrellas T Tauri son estrellas de baja masa de pre-secuencia principal. Estos objetos están rodeados por un disco de acreción y presentan una poderosa actividad magnética. Las estrellas T Tauri son copiosas emisoras de rayos X. Los rayos X se generan en eventos intensos de reconexión magnética. Ondas de choque fuertes pueden estar asociadas con la reconexión masiva del campo magnético. Estas ondas o la propia reconexión pueden acelerar partículas hasta energías relativistas, como se ha observado en el sol. Presentamos un modelo para la radiación de muy alta energía producida en la magnetósfera de las estrellas T Tauri. Discutimos si esta emisión es detectable o no con los telescopios de rayos gamma existentes.

ABSTRACT

T Tauri stars are low mass, pre-main sequence stars. These objects are surrounded by an accretion disk and present strong magnetic activity. T Tauri stars are copious X-rays emitters. The X-rays are likely generated by powerful magnetic reconnection events. Strong shocks can be produced by massive reconnection in the stellar magnetosphere. These shocks or the reconnection of the field might accelerate particles up to relativistic energies, as observed in the Sun. We present a model for the high-energy radiation produced in the magnetosphere of T Tauri stars. We discuss whether this emission is detectable with the existing gamma-ray telescopes.

Key Words: gamma rays: stars — radiation mechanisms: non-thermal — stars: pre-main sequence

1. GENERAL

The aim of this work is to determine whether T Tauri stars can emit high-energy radiation and to establish whether the high-energy emission is detectable. T Tauri stars are low-mass pre-main sequence stars. These objects have accretion disks. The accretion of plasma occurs through magnetically confined columns. These stars drive strong winds and the youngest ones produce jets. T Tauri stars emit thermal X-ray radiation. This radiation corresponds to a plasma of typical temperature of $\sim 10^7$ K. This emission is variable and produces flares that are thought to be related to strong magnetic reconnection events (see Feigelson & Montmerle 1999).

The reconnection processes move the magnetospheric plasma producing shock waves. These shocks can accelerate particles up to relativistic energies (e.g., Schopper, Lesch, & Birk 1998; de Gouveia Dal Pino, Piovezan, & Kadowaki 2010). High-energy particles interact with the fields in the source: the magnetic field, the matter field and the radiation field. These interactions can give rise to gamma-ray radiation.

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2. CALCULATIONS

We consider a spherical magnetosphere of radius $R = 0.1$ AU. The magnetic field is $B \sim 5 \times 10^2$ G and the maximum plasma density is $n \sim 10^{11}$ cm^{-1}. An estimate of the power available in the system is

$$L \sim \frac{B^2}{8\pi} Ac, \tag{1}$$

where A is the magnetosphere area. We assume that 10% of this power is release in the reconnection process, and 0.01% of the latter is transformed into relativistic particles.

We assume besides that the relativistic particles (electrons and protons) are injected in the magnetosphere with a power law distribution with power-law index $\alpha = 2$. These particles lose energy through the interactions with the fields in the magnetosphere. The electrons lose energy mainly through synchrotron mechanism, relativistic Bremsstrahlung, and inverse Compton radiation. The protons lose energy through synchrotron and (mainly) proton-proton inelastic collisions. Figure 1 shows the radiative looses and the acceleration rate for electrons and protons.

The particles distribution is calculated solving the corresponding transport equation (e.g., Ginzburg & Syrovatskii 1964):