827/E1

A method to estimate the cooling time of ultra-relativistic electrons in Pulsar Wind Nebulae

K L I Gunawardhana[1], A U Abeysekara[2], K P S C Jayaratne[1*] and J Adassuriya[3]
[1]*Department of Physics, Faculty of Science, University of Colombo, Colombo 03, Sri Lanka.*
[2]*Departments of Physics and Astronomy, Michigan State University, USA*
[3]*Arthur C Clarke Institute for Modern Technologies, Katubedda, Moratuwa, Sri Lanka*

Pulsars are highly magnetized rotating neutron stars that produce two photon jets along the magnetic dipole axis, and an out-flowing wind of relativistic electrons and positrons, known as pulsar wind. Pulsar winds create nebulae around pulsars, which are known as Pulsar Wind Nebulae (PWNe). PWNe are continuously powered by the pulsar wind.Data gathered from Imaging Air Cherenkov type Telescope High Energy Stereoscopic System (H.E.S.S.) in 2005 and the Satellite type Fermi Large Area Telescope (Fermi-LAT) in 2010 and 2011 were used in this research for the analysis. There were 34 PWNe detected in the TeV energy band. The current understanding is, these TeV photons are produced from up-scattering of low-energy photons to high-energies by the ultra-relativistic electrons and positrons in PWNe, which is a non-thermal process. This process is known as inverse-Compton scattering. During inverse-Compton scattering, ultra-relativistic electrons lose their energy and cool-down to low-energies. The average time that an ultra-relativistic electron takes to cool-down by inverse-Compton scattering is called as the cooling time. Estimation of cooling time is important in understanding the luminosity evolution of PWNe, and the correlations between pulsars and their associated PWNe.

This paper describes a method developed to estimate the cooling time of PWNe. In order to estimate the cooling time due to inverse-Compton scattering of a given PWN, two parameters were used: the total number of ultra-relativistic electrons injected into the PWN, and the total number of electrons cooled down by inverse-Compton scattering. The current rate of electron injection to PWN is proportional to the rate of loss of rotational kinetic energy (spin-down luminosity) of the associated pulsars. Then the total number of electrons injected can be calculated using the time evolution of the spin-down luminosity. The present rate of electron cooling is proportional to the integrated energy in the inverse-Compton peak, where inverse-Compton scattering is the dominant emission mechanism. Thereafter, the total number of electrons cooled is calculated using the time evolution of the spectrum.

Keywords: Cooling time, neutron stars, non-thermal, pulsars, spin-down luminosity

chandanajayaratne@gmail.com Tel: 0714800800