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Probing pulsar winds using inverse Compton scattering

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Abstract. We investigate the modifications to the calculations of inverse Compton scattering by the wind of pulsar B1259−63 due to the inclusion of a realistic spectrum for the target photons from the pulsar's Be-star companion.

1. Introduction

The wind of the rotation-powered PSR B1259−63 (e.g. Johnston et al. 1996) encounters an enormous density of photons from the pulsar's companion star. Electrons and positrons in the wind inverse Compton scatter these target photons to energies as high as 10^{12} eV. The resulting flux of scattered photons will be variable because of the pulsar's eccentric orbit, and is likely to be detectable with ground-based atmospheric imaging Cerenkov telescopes (Kirk, Ball & Skjæraasen 1999a & 1999b; Ball & Kirk 1999; Chernyakova & Illarionov 1999). Ball & Kirk (1999) considered the scattering by the unshocked region of the pulsar wind, approximating the target photon spectrum by a monochromatic distribution at the average energy of the Be star photons. Here we recalculate the effects of the scattering using a realistic spectrum for the target photons.

2. Results

The pulsar companion, SS2883, is a B2-IV star with $T_{\rm eff} \approx 21000$ K. We use a a model stellar spectrum from Kurucz (1979) with a surface gravity of 4.0. The emission from the surrounding disk can be modelled as that from a hydrogen 'envelope' with $T \sim 10000$ K (Dachs et al. 1989). In order to fit the observed J, H & K-band near infra red magnitudes of SS2883 (Coe et al. 1997) we add a lower-temperature black body spectrum, the temperature of which is reasonably well constrained to around 2000 K. The resulting number spectrum of the target photons is quite broad (see Fig. 1a) but the energy spectrum – which determines the properties of the inverse Compton scattering – is much more sharply peaked.

The effects of including this more realistic target photon spectrum are generally small. The wind is decelerated slightly more rapidly because the integrated

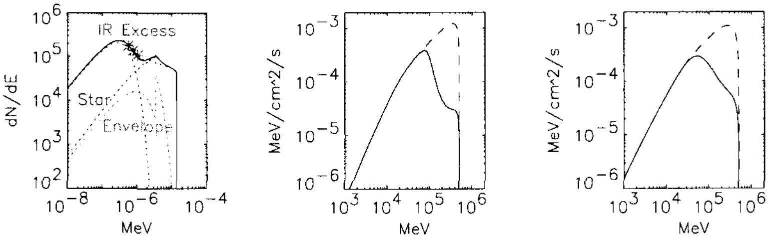

Figure 1. The differential number spectrum of the target photons showing the contribution from the star, the envelope (disk), and an additional 2000K black body, is shown in (a). The energy spectrum of inverse Compton scattered photons from PSR B1259-63 for a wind Lorentz factor of 10^6 along a line of sight at $5°$ to the line joining the pulsar to its companion, for monochromatic targets (b) and the composite target spectrum (c). The solid lines include the effects of pair creation on the target photons.

target photon density is higher than in the monochromatic targets case, which did not include the luminosity of the envelope or the IR excess. The spectrum of the photons scattered from the composite target is generally smoother than for the case of monochromatic targets, as illustrated by the dashed curves in Fig. 1b and 1c. The scattered spectrum is somewhat broader in Fig. 1c, and the transition between Thompson and Klein-Nishina scattering – visible as a flattening above $\sim 10^4$ eV in Fig. 1b – is much less pronounced in Fig. 1c. The modifications of the spectra are more easily seen when the effects of pair creation by the scattered γ-rays on the same target photon distribution are included. The large range of target photon energies smooths out the threshold for pair creation – the minimum energy the scattered photons must have if they are to pair create on the target photons – so the resulting dramatic dip in the scattered photon spectrum for monochromatic targets (solid curve, Fig. 1b) is smoother for the composite target spectrum (solid curve, Fig. 1c). The modifications to the light curves due to the target photon spectrum are typically small, but may warrant further investigation if this system is detected in hard γ-rays.

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