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Compton Scattering Cross Sections in Strong Magnetic Fields: Advances for Neutron Star Applications

Various telescopes including RXTE, INTEGRAL, Suzaku and Fermi have detected steady non-thermal X-ray emission in the 10 ˜ 200 keV band from strongly magnetic neutron stars known as magnetars. Magnetic inverse Compton scattering is believed to be a leading candidate for the production of this intense X-ray radiation. Generated by electrons possessing ultra-relativistic energies, this leads to attractive simplifications of the magnetic Compton cross section. We have recently addressed such a case by developing compact analytic expressions using correct spin-dependent widths acquired through the implementation of Sokolov & Ternov (ST) basis states, focusing specifically on ground state-to-ground state scattering. Such scattering in magnetar magnetospheres can cool electrons down to mildly-relativistic energies. Moreover, soft gamma-ray flaring in magnetars may well involve strong Comptonization in expanding clouds of mildly-relativistic pairs. These situations necessitate the development of more general magnetic scattering cross sections, where the incoming photons acquire substantial incident angles relative to the field in the rest frame of the electron, and the intermediate state can be excited to arbitrary Landau levels, which are necessarily spin-dependent. In this paper, we highlight numerical results from such a generalization using ST formalism. The cross sections treat the plethora of harmonic resonances associated with various cyclotron transitions between Landau states. Polarization dependence of the cross section for the four scattering modes is illustrated and compared with the non-relativistic cross sections. Results will find application to various neutron star problems, including computation of Eddington luminosities and polarization mode-switching rates in transient magnetar fireballs.

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