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Synchrotron radiation as the origin of spectral cutoff in ultraluminous X-ray sources

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Ultraluminous X-ray sources are the X-ray binaries with X-ray luminosity exceeding the Eddington limit of a 10 solar mass black hole. Recent consensus is that these sources are powered mainly by super-Eddington accretion onto stellar-mass compact objects. An increasing number of discovered pulsating ULXs further advocate a possible scenario that neutron stars dominate a significant fraction of the ULX population. Modern X-ray observatories have confirmed that most ULXs, if not all, show a characteristic spectral cutoff around 10 keV. Such a finding warrants a generalized physical origin explaining the cutoff. We discuss a novel theoretical model that can explain this X-ray spectral cutoff with the underlying physics of synchrotron radiation. The velocity distribution of the plasma particles, the emission angle of the radiation, and the magnetic field strength are the primary factors determining the cutoff energy. Depending on the velocity distribution of the particles, a semi-relativistic plasma with a high-latitude angle or a highly relativistic plasma with emission close to the orbital plane of the electron can adequately explain this cutoff. We discuss how the cutoff appears analytically from the properties of Bessel functions using stationary-phase approximations. We also discuss the congruence between the theoretical model and the data for some ULXs and investigate the physical parameters in these sources. As a corollary, we find that if this new model explains the origin of such characteristic spectral cutoff in these sources, most ULXs are neutron stars.

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