Interstellar Medium, Black Holes and Magnetized Neutron Stars

The **Interstellar Medium**, like the Ocean Mother, is the place of issue of most things, and was my first astrophysics interest. It is a rich arena, carrying the traces of everything that happened in the Universe since the earliest times. The structure of interstellar clouds, the intercloud medium and the intergalactic medium involve a fascinating combination of gasdynamics, atomic and statistical physics and radiative transfer. My work in this field explored new problems in the evolution of interstellar clouds [1, 2] and the nature of the ionizing agents of clouds and the intercloud medium [3, 4].

Black Holes are the end-point of the evolution of stars more massive than about $25M_\odot$, and lead to some of the more interesting galactic X-ray sources, such as Cyg X-1, as well as some of the most powerful extragalactic sources, such as quasars. While in binary systems the accretion typically leads to a disk, spherical accretion can also proceed with significant radiative efficiency [5, 6]. In the early universe [7], the presence of high redshift quasars emphasizes the importance of understanding how fast can black holes grow, a question addressed in an essay which won the first prize of the Gravity Research foundation [8]. The most powerful explosions in the Universe, Gamma-Ray Bursts, are thought to be the results of special conditions in the collapse of massive stars, and these explosions are being detected out to the most distant confines of the Universe (discussed in another section).

Neutron stars are the densest material objects in the Universe (outside of blackholes); their density is comparable to that of an atomic nucleus. Many of them have very large magnetic fields, of order 10^{12} Gauss (10^8 Tesla). Some are in binary systems and accrete matter from the the companion, and as they rotate they emit pulsed X-rays. In such X-ray pulsars the X-ray radiation originates mostly in the accretion columns above the polar caps. The typical temperatures and photon energies are in the 10-30 10 keV range, and the radiative transfer problem is complicated by the anisotropies and frequency dependence induced by the strong magnetic field. The elementary radiative processes and the radiative transfer require detailed treatment, where cyclotron line formation [10, 9, 11] plays a large role, as well as gravitational lensing [13], and novel effects arise due to quantum vacuum polarization effects [12]. Much of the early work on these problems was summarized in a book [14].

Magnetars are ultra-high magnetic field ($\gtrsim 10^{14}$ Gauss) neutron stars, which give rise to soft-gamma repeater (SGRs) bursts. These are thought to be due to magnetic reconnection leading to a fireball where shocks will Fermi accelerate electrons and protons leading to photomeson effects [15]. A novel mechanism arises in non-bursting magnetars, where for fields $\gtrsim 10^{15}$ Gauss the equivalent of curvature radiation can lead directly to pions and neutrinos [16]. In newly formed magnetars, wake-field acceleration can lead to ultra-high energy proton acceleration, which interact with the ejected supernova shell targets leading to potentially detectable neutrino fluxes [17].

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