

cal understanding of the SPL state is required as a foundation for building any complete model of the HFQPO mechanisms, a topic considered in further detail in §8.2.4.

8 Accreting Black Holes as Probes of Strong Gravity

The continuing development of **gravitational wave astronomy** is central to the exploration of BHs. In particular, we can reasonably expect that **LIGO** and **LISA** will provide us with intimate knowledge concerning the behavior of space-time under the most extreme conditions. Nevertheless, gravitational wave detectors are unlikely to provide us with direct information on the formation of relativistic jets, on strong-field relativistic MHD accretion flows, or on the origin of high-frequency QPOs or broadened Fe lines. Accreting BHs – whether they be stellar-mass, supermassive or intermediate mass – promise to provide detailed information on all of these topics and more. In short, accreting BHs show us uniquely how a BH interacts with its environment. In this section, we first sketch a scenario for the potential impact of BHBs on physics, and we then discuss a current frontier topic, namely, the measurement of BH spin.

8.1 Black Holes Binaries: The Journey from Astrophysics to Physics

Astrophysics has a long history of impacting physics: e.g., Newton’s and Einstein’s theories of gravity, the ongoing research on dark matter and dark energy, the **equation of state** at supranuclear densities, and the **solar neutrino puzzle**. Likewise, astrophysical BHs have the potential to revolutionize classical BH physics; after all, the only real BHs we know, or are likely ever to know, are astrophysical BHs. But how can BHBs contribute to the study of BH physics? Very roughly, we envisage a five-stage evolutionary program that is presently well underway.

Stage I—*Identify Dynamical BH Candidates*: This effort is already quite advanced (see §1 and Table 1) and represents an important step because mass is the most fundamental property of a BH. Nevertheless, the dynamical data do not probe any of the effects of strong gravity, and therefore we curtail the discussion of Stage I.

Stage II—*Confirm that the Candidates are True Black Holes*: Ideally, in order to show that a dynamical BH candidate (i.e., a massive compact object) is a genuine BH, one would hope to demonstrate that the candidate has an event horizon – the defining characteristic of a BH. Strong evidence has been obtained for the reality of the event horizon from observations that compare BHBs with very similar neutron-star binaries. These latter systems show signatures of the hard surface of a neutron star that are absent for the BH systems. For example, X-ray observations in quiescence show that the BH systems are about 100 times fainter than the nearly identical neutron-star binaries (Narayan et al. 1997; Garcia et al. 2001). The ADAF model (§7) provides a natural explanation for the faintness of the BHs, namely, the low radiative efficiency of the accretion flow allows a BH to “hide” most of its accretion energy behind its event horizon (e.g., Narayan et al. 2002). In quiescence, one also observes that BHs lack a soft thermal component of emission that is very prevalent in the spectra of neutron stars and can be ascribed to surface emission (McClintock, Narayan, & Rybicki 2004). During outburst, the presence of a surface for an accreting neutron star