

likewise gives rise to distinctive phenomena that are absent in BHBs: (a) **type I thermonuclear bursts** (Narayan & Heyl 2002; Tourneir et al. 2003; Remillard et al. 2006a), (b) high-frequency timing noise (Sunyaev & Revnivtsev 2000), and (c) a distinctive spectral component from a boundary layer at the stellar surface (Done & Gierliński 2003).

Of course, all approaches to this subject can provide only indirect evidence for the event horizon because it is quite impossible to detect directly any radiation from this immaterial surface of infinite redshift. Nevertheless, barring appeals to very exotic physics, the body of evidence just considered makes a strong case that dynamical BH candidates possess an event horizon.

Stage III—Measure the Spins of Black Holes: An astrophysical BH is described by two parameters, its mass M and its dimensionless spin parameter a_* . Because the masses of 20 BHs have already been measured or constrained (see Stage I and §2), the next obvious goal is to measure spin. Indeed, several methods to measure spin have been described in the literature, and various estimates of a_* have been published, although few results thus far can be described as credible. We consider this stage to be a central and active frontier in BH research. Consequently we return to this subject below, where we discuss four approaches to measuring spin and some recent results for two BHBs.

Stage IV—Relate Black Hole Spin to the Penrose Process and Other Phenomena: A number of phenomena observed in astrophysical BHs have been argued to be associated with BH spin. The most notable examples are the explosive and relativistic radio jets associated with the hard-to-soft X-ray transition that occurs near the jet line (§4.3). Such ejections have been observed for at least eight BHBs and BHCs (Mirabel & Rodriguez 1999; Fender & Belloni 2004; McClintock & Remillard 2006 and references therein). Also, large-scale relativistic X-ray jets have been reported for XTE J1550-564 (Hannikainen et al. 2001; Corbel et al. 2002) and H 1743-322 (Corbel et al. 2005). For many years, scientists have speculated that these jets are powered by BH spin via something like the **Penrose (1969) process**, which allows energy to be milked from a spinning BH. Detailed models generally invoke magnetic fields (Blandford & Znajek 1977; Hawley & Balbus 2002; Meier 2003; McKinney & Gammie 2004). A number of beautiful ideas have been published along these lines, but there has been no way of testing or confirming them. Recently, however, some progress has been made on measuring BH spin, and it may soon be possible to attack the jet-spin/Penrose-process connection in earnest.

Stage V—Carry out Quantitative Tests of the Kerr Metric: One of the most remarkable predictions of BH physics is that the space-time surrounding a stationary rotating BH is described by the Kerr metric, which is completely specified by just two parameters, M and a_* . Testing this prediction is the most important contribution astrophysics can make to BH physics. Obviously, in order to carry out such a test, one must first measure M and a_* with sufficient precision (Stage III). Once suitable measurements of M and a_* have been amassed for a number of BHs, we presume that astronomer’s will be strongly motivated to devise ways of testing the metric, a topic which is beyond the scope of this work.

8.2 Measuring Black Hole Spin: A Current Frontier

We now elaborate on Stage III by discussing four avenues for measuring BH spin. These include (a) X-ray polarimetry, which appears very promising but