3.2 NGC 3115: $M_\bullet \simeq 10^{9.0\pm0.3}$ M$_\odot$

One of the best stellar-dynamical BH cases is the prototypical S0 galaxy NGC 3115 (Fig. 1). It is especially suitable for the BH search because it is very symmetrical and almost exactly edge-on. NGC 3115 provides a good illustration of how the BH search makes progress. Unlike some discoveries, finding a supermassive BH is rarely a unique event. Rather, an initial dynamical case for a central dark object gets stronger as observations improve. Eventually, the case becomes definitive. This has happened in NGC 3115 through the study of the central star cluster – a tiny, dense cusp of stars like those expected around a BH (Figure 1). Later, still better observations may accomplish the next step, which is to strengthen astrophysical constraints enough so that all plausible BH alternatives (clusters of dark stars) are eliminated. This has happened for our Galaxy (§ 3.4) but not yet for NGC 3115.

The kinematics of NGC 3115 show the signature of a central dark object (Fig. 2). The original detection was based on the blue crosses. Already at resolution $\sigma_* = 0\farcs44$, the central kinematic gradients are steep. The apparent central dispersion, $\sigma \simeq 300$ km s^{-1}, is much higher than normal for a galaxy of absolute magnitude $M_B = -20.0$. Therefore, isotropic dynamical models imply that NGC 3115 contains a dark mass $M_\bullet \simeq 10^{9\pm0.3}$ M$_\odot$. Maximally anisotropic models allow smaller masses, $M_\bullet \sim 10^8$ M$_\odot$, but isotropy is more likely given the rapid rotation.

Since that time, two generations of improved observations have become available. The green points in Figure 2 were obtained with the Subarcsecond Imaging Spectrograph (SIS) and the Canada-France-Hawaii Telescope (CFHT). This incorporates tip-tilt optics to improve the atmospheric PSF. The observations with the *HST* Faint Object Spectrograph (FOS) have still higher resolution. If the BH detection is correct, then the apparent rotation and dispersion profiles should look steeper when they are observed at higher resolution. This is exactly what is observed. If the original dynamical models are "reobserved" at the improved resolution, the ones that agree with the new data have $M_\bullet = (1$ to $2) \times 10^9$ M$_\odot$.

Figure 1. *HST* WFPC2 images of NGC 3115. The left panel shows a color image made from 1050 s V- and I-band images. The right panel shows a model of the nuclear disk. The center panel shows the difference; it emphasizes the compact nuclear star cluster. Brightness is proportional to the square root of intensity. All panels are $11\farcs6$ square. [This figure is taken from Kormendy *et al.* 1996, *Astrophys. J. Lett.*, **459**, L57.]