Compact objects in globular clusters

Tom Maccarone (Texas Tech University), Laura Chomiuk, Jay Strader, Steve Zepf (Michigan State University), Dave Pooley (Sam Houston State University), Josh Grindlay (Harvard University), Mike Shara, Dave Zurek (AMNH), Steinn Sigurdsson (Penn State), Steve McMillan (Drexel)

Globular clusters are the best laboratories in the Universe for studying both the physics of low mass stars and the physics of stellar dynamics. Additionally, their high stellar densities make them factories for producing binaries with compact objects. The implications of these compact binaries extend over a broad range of astrophysics.

In particular, theoretical calculations suggest that globular clusters may produce ten times as many Type Ia supernovae per unit stellar mass as field star populations (Shara & Hurley 2002) – which would mean that globular clusters would dominate Type Ia production at high redshifts where they make up about 10% of star formation (Vesperini et al. 2010). They may also dominate the rates of mergers of black holes with neutron stars (Clausen, Sigurdsson & Chernoff 2012). Dynamically formed double neutron stars have been suggested to be the progenitors of short gamma-ray bursts (Grindlay, Portegies Zwart & McMillan 2006). Globular clusters are also suggested to be the sites of formation of intermediate mass black holes (e.g. Noyola & Gebhardt 2006), and hence may be prime locations for detecting longer wavelength gravitational wave sources, and may provide the seeds needed to grow supermassive black holes fast enough to see quasars at high redshift. Globular clusters also contain about half of all known millisecond pulsars. Additionally, close binaries represent the energy source that prevents core collapse of globular clusters (e.g. Heggie 1975; Goodman & Hut 1989; Fregeau 2008).

While a comprehensive understanding of how these compact object binaries form is not present, dramatic progress has been made in the past decade. Where it was once commonly believed that globular clusters should dynamically eject all their stellar mass black holes, they are now frequently being discovered as variable ultraluminous X-ray sources in extragalactic globular clusters (e.g. Maccarone et al. 2007), and have even been discovered in our own Galaxy's globular clusters as quiescent black hole X-ray binaries (Strader et al. 2012). The extragalactic work requires high angular resolution X-ray *and* optical data, and also requires the capability to make repeated observations to discover variable X-ray sources. Since the transients which exceed the Eddington luminosity of a neutron star often have very long outburst durations (decades or more, like GRS 1915+105), one can expect to continue to see more and more interesting objects even by continuing to observe the same galaxies; additionally, it should be straightforward to detect globular cluster black holes well past the $\sim$ 20Mpc distance out to which known objects are located.

At the same time, many more quiescent black hole X-ray binaries may be lurking in our own Galaxy. While new radio data will help find these objects, truly understanding them will require identification and follow-up of their optical counterparts. Ultraviolet observations have repeatedly been shown to be very efficient at isolating interesting compact objects from the confusing sea of normal stars (e.g. Knigge et al. 2008), and spectroscopy with large effective area and good spatial resolution will be needed to follow-up such objects to make mass estimates and determine, e.g. whether the mass distribution of black holes in globular clusters skews to higher mass than that of field star low mass X-ray binaries (which is to be expected, since the field star X-ray binaries form through common envelope evolution, and generally form at higher metallicity).

Continued progress on detecting and characterizing black holes, neutron stars and white dwarfs in binary systems in Galactic and extragalactic globular clusters is an interesting topic in its own right, and a key to developing our understanding of whether and how dynamically formed binaries contribute to both gravitational wave source production and production of some of the most important and exciting explosive events in the Universe. Space-based observations represent a fundamentally important component of this work.