MINI-DISK DYNAMICS ABOUT SUPERMASSIVE BLACK HOLES BINARIES

**Research Challenge**

The research focus is on mini-disk simulations, which are first-of-a-kind comprehensive general relativistic magnetohydrodynamic (GRMHD) simulations of accreting supermassive black holes (SMBHBs). Including the mini-disks is critically important to understand the EM signatures. Mini-disks make up a large fraction of the total luminosity from the system, and give rise to the most variable emission, which is key for astronomers in characterizing and identifying SMBHBs.

**Methods & Codes**

- A flux-conservative, high-resolution, shock-capturing general relativistic magnetohydrodynamic (GRMHD) code, HARM3d, is used.
- GRMHD is written in a way so that any metric or coordinate system may be adopted, which accommodated the implementation of a novel, time-dependent, non-uniform gridding scheme to resolve the huge scale differences for features near and far away from black holes.

**Results & Impacts**

- 2D hydrodynamic simulations found significant mass exchange occurred between the two mini-disks. Also, binaries near merger will be bright and periodic at a time scale associated with the SMBHB's orbital period—a key to extracting information about an observed binary's orbit.
- The first full 3D MHD evolution simulation of mini-disks about black hole binaries in the relativistic regime, including the accretion from the circumbinary disk, will begin to address the importance of spiral shocks and the interaction between the mini-disks circumbinary gas.

**Why Blue Waters**

Blue Waters’ capability and support has made the simulation of two orbital periods using 12.9 million floating-point-core-hours possible. The simulation used 600x160x640, or approximately 60 million cells, on about 2 million time steps, and took about one month to complete. The simulation is challenging because of the large dynamic range of time scales between the fast behavior near the black holes and the relatively slow orbital velocity of the binary.