The need for Gemini:

Doppler tomography is an indirect, distance-independent imaging technique that allows us to reconstruct the accretion flows in galactic X-ray binaries on otherwise-inaccessible micro-arcsecond scales. This may be one of the best means of finding differences in the disk structures of systems that contain black holes or neutron stars.

In order to construct well-resolved tomograms we require velocity resolution suitable to study features from a few tens to thousands of km/sec and temporal resolution that allows 40-100 phase bins around the binary orbit. The integration time, t, required to resolve a feature of speed K without “blurring” by the rotation periods is (Marsh 2001):

\[
 t = \frac{P}{(2\pi) \times (\Delta V/K)}
\]

GMOS-N and GMOS-S are ideal for the short period (less than one day) systems that pose a particular challenge by requiring a rapid cadence of high signal-to-noise spectra of optically-faint sources. Furthermore, the combination of Gem_N and Gem_S provides the whole sky coverage needed to obtain samples of all source categories.

References:


Tomographic Imaging of Black Hole and Neutron Star Binaries:

The need for Gemini observations

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Introduction:

X-ray binaries (XRBs) consisting of a normal star orbiting a compact object such as a neutron star (NS) or a stellar mass black hole (BH) owe their prominence to one of the most efficient energy release mechanisms known: accretion onto a compact object. But 50 years after their discovery we still have no direct means for obtaining samples of all source categories. The microquasar J1118+480 with a size = 2.7R⊙ and at a distance of 2 kpc subtends a mere 6 X 10⁻⁶ arcseconds. The combination of Gem_N and Gem_S provides the whole sky coverage needed to obtain samples of all source categories.

An example of optical tomography:

Keck II observations of the micro-quasar XTE J1118+480

Above: The disk and the surface of the companion star produce both emission and absorption features. Schematic courtesy R. Hynes.

Above Left: Tomogram of Call showing the disk in emission (blue). Location of Call in absorption from the secondary (shiki) cleared up a long-standing discrepancy in the accreting column to this object. Above Right: The four Na lines all appear in absorption at the secondary. The line profile expected from a simple Keplerian disk is broadened by the large velocities of the emitting gas. Doppler tomography takes such data sets and reconstructs the distribution of emission in a velocity coordinate frame. The data set provided us with observed radial velocities of the emitting gas. Doppler tomography takes such data sets and reconstructs the distribution of emission in the binary frame that reproduce the profiles in detail. The various components of the accretion flow leave distinct imprints in the recorded images. Emission from the accretion disk, the gas stream and the stellar components can be clearly separated. This provides us with information on disk sizes and shapes, positions of stream trajectories, the ratios between disk and star luminosity, and the location and variability of emitting regions at various temperatures.

Above left: The line profile expected from a simple Keplerian disk is broadened by the large velocities of the emitting gas. The contribution of a particular location is Doppler shifted due to its radial velocity relative to the observer. Observing a time-series of line profiles provides the radial velocities of the emitting gas allowing us to reconstruct the disk image in velocity space. Since velocities in a disk increase toward the center of the disk, the disk appears inverted in velocity space. Above right: The relationship between coordinate and velocity space (Marsh 2001, 2005).

Doppler Tomography

The images reconstructed using Doppler tomography present the distribution of emission in a velocity coordinate frame. The data set provides us with observed radial velocities of the emitting gas. Doppler tomography reconstructs the distribution of emission in the binary frame that reproduce the profiles in detail. The various components of the accretion flow leave distinct imprints in the recorded images. Emission from the accretion disk, the gas stream and the stellar components can be clearly separated. This provides us with information on disk sizes and shapes, positions of stream trajectories, the ratios between disk and star luminosity, and the location and variability of emitting regions at various temperatures.

Above left: Tomogram of Call showing the disk in emission (blue). Location of Call in absorption from the secondary (shiki) cleared up a long-standing discrepancy in the accreting column to this object. Above right: The four Na lines all appear in absorption at the secondary. The line profile expected from a simple Keplerian disk is broadened by the large velocities of the emitting gas. Doppler tomography takes such data sets and reconstructs the distribution of emission in a velocity coordinate frame. The data set provided us with observed radial velocities of the emitting gas. Doppler tomography takes such data sets and reconstructs the distribution of emission in the binary frame that reproduce the profiles in detail. The various components of the accretion flow leave distinct imprints in the recorded images. Emission from the accretion disk, the gas stream and the stellar components can be clearly separated. This provides us with information on disk sizes and shapes, positions of stream trajectories, the ratios between disk and star luminosity, and the location and variability of emitting regions at various temperatures.

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