DETERMINING HOW THE TRUE REFLEX MOTIONS AND DYNAMICAL ORBITS FOR INTERACTING BINARIES DEPEND ON PHOTOCENTER CONTAMINATION

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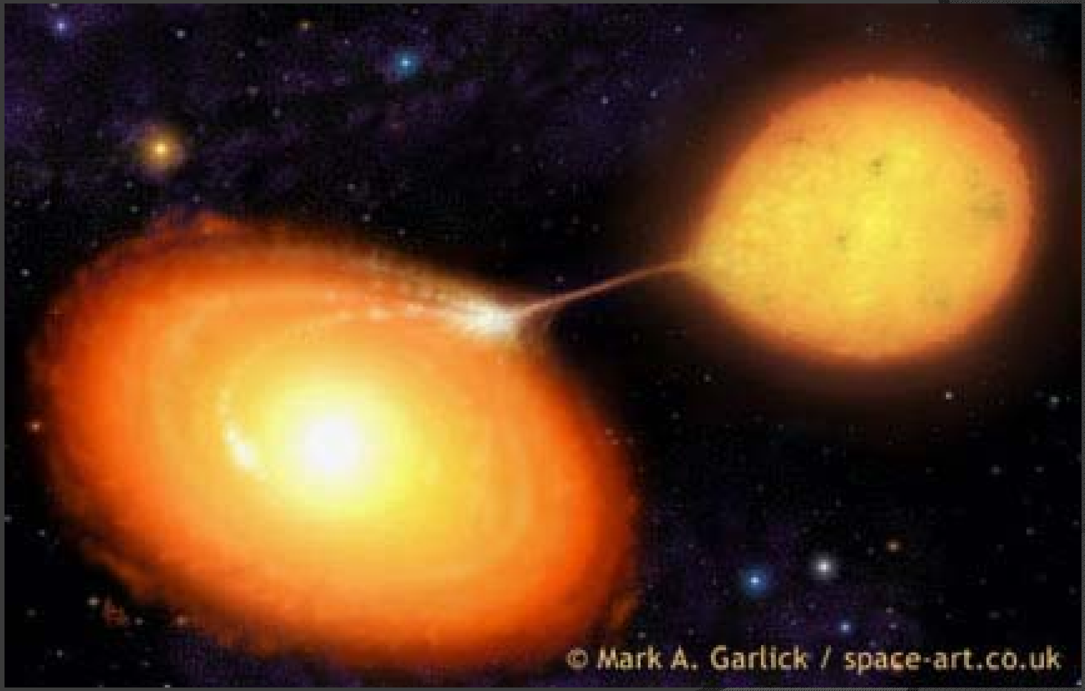
Interacting Binaries

- 3 components: BH/NS/WD primary, secondary, and emission from accretion
- Lots of unanswered ??s in binary star evolution
  - CE phase
  - Extreme mass ratios
  - CNO cycle evidence
  - Component progenitors
- Precise and accurate masses of both components are needed to constrain evolutionary models
- Precise and accurate distances are needed to learn about the energetics and interactions of the binary components



Masses and Orbits: How Can SIM Help?

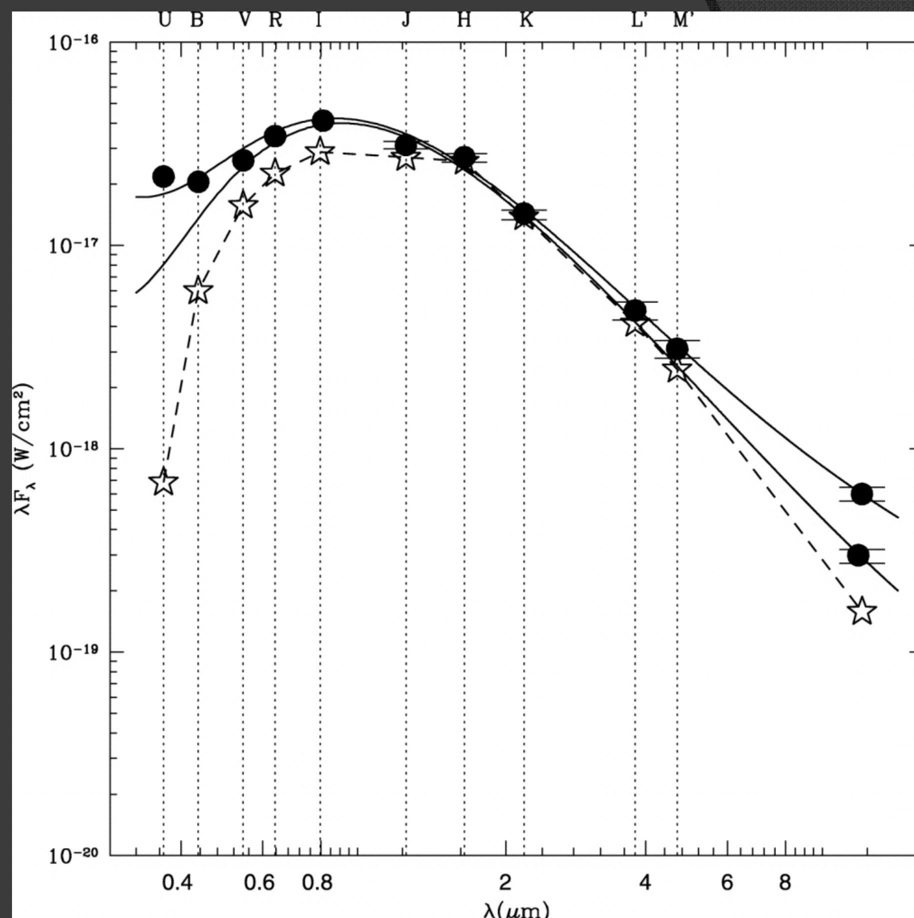
- Astrometric measurements of binary star reflex orbits would be ideal but are not easy in this case
- Need a complete orbital solution to derive the component masses
- Direct measurement of astrometric and radial velocity orbits circumvents this problem, yielding accurate masses for both components
  - SIM can measure reflex motions of an array of IBs, but accretion luminosity will affect the determination of accurate orbits across the full spectrum of masses.
  - Every SIM program intending to measure the masses of stellar components in interacting binary systems will be affected by the presence of ongoing accretion
- How does accretion contamination affect our ability to measure a precise and accurate dynamical orbit?

SIM Science Programs

- Distances and Orbits of interacting binaries will be attempted with SIM (distances should be easy)
- "Masses and Luminosities of X-Ray Binaries"
  PI - A. Quirrenbach (SIM Data Scientist)
  - 50 targets including 5 narrow angle:
    - BH Candidates: Cyg X-1, GRO J1655-40
    - NS candidates: Vela X-1, 4 U 1907+09, GX 301-2
- "Exceptional Stars Origins, Companions, Masses and Planets" PI – S. Kulkarni (SIM Interdisciplinary Scientist)
  - Array of topics including:
    - Masses and radii of NS
    - Origin of LMXBs
    - Most massive stellar-massed BH
    - SS 433
- Without taking into account photocenter contamination, SIM results may not accurately determine component masses

An Example: SS Cyg

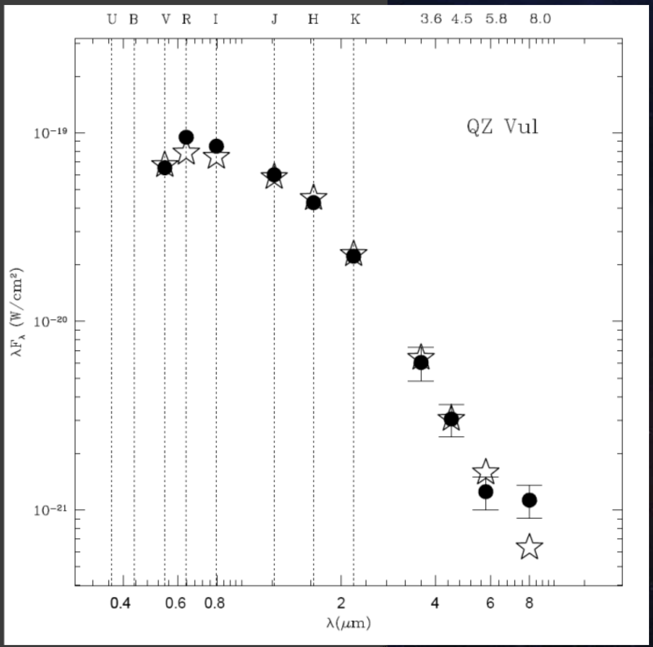
- Non-magnetic CV: WD + K5V
  - P_{orb} = 6.6 hrs (long period)
  - $q = 0.69 \pm 0.02$
  - a = 81 μas
  - WD and accretion disk dominate blue (< V) while secondary dominates the red (> V)
- Location of photocenter and subsequent motion is strongly wavelength dependent due to accretion disk
  - If SS Cyg disk symmetric about the primary => no motion @ ~5500Å but ~54 μas at red end
    →``curve of growth'' associated with each system that will asymptotically approach the true value for the reflex motion towards redder wavelengths

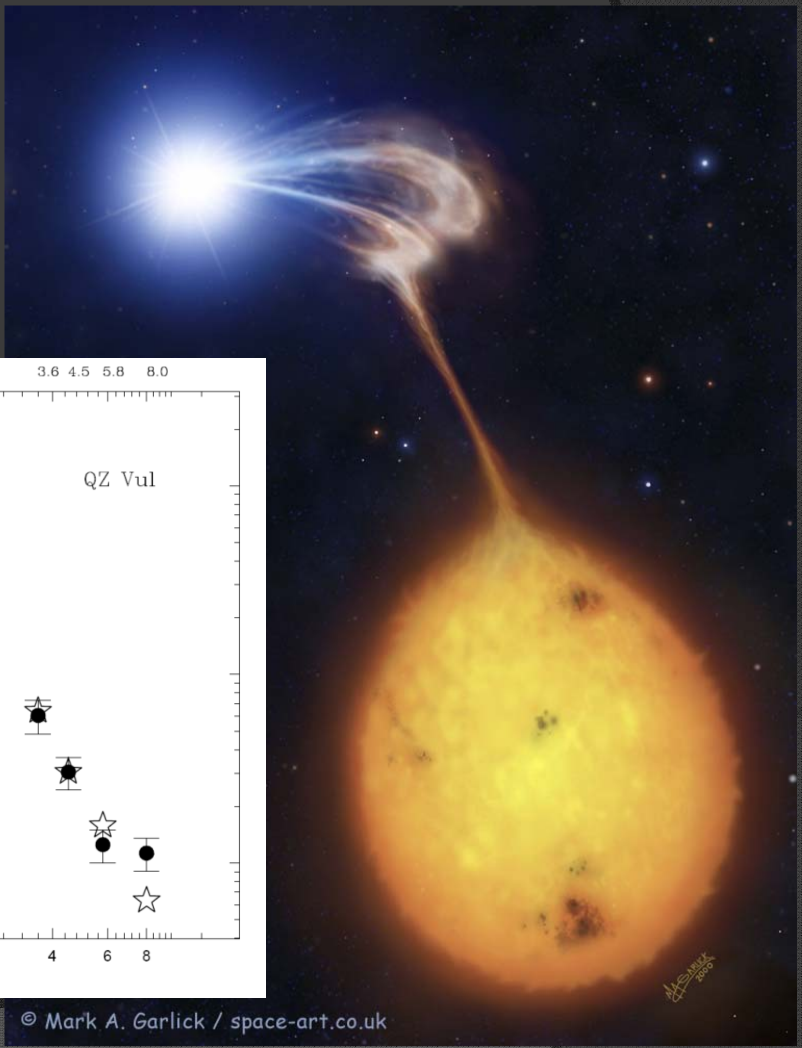


Circles = SS Cyg SED from Dubus et al. (2004) + IRTF *L'* data; Stars = K5V SED; lines = BB + free-free non-flaring (lower) and flaring (upper) models

An Example: Other systems

- Magnetic CVs (right):
  - Can be easier because the secondary or primary can dominate the optical SED
  - Caveat: cyclotron can dominate optical
- Black Hole and Neutron Star systems:
  - Secondary star can dominate the entire optical SED while in quiescence





Study Questions

1. How does the accretion luminosity contamination affect our ability to determine dynamical orbits in interacting binary systems?
2. How can the SIM observations themselves be used to isolate the different optical components within the interacting binary systems?
3. What are the best targets to observe with SIM?

Technical Approach

- Build a BH/NS/WD interacting binary source list
  - Include orbital parameters, distance, photometry, stellar types, component masses, accretion states
  - Build a multi-component model for each type of source
  - Compile a list of potential reference stars to determine narrow angle vs. wide angle modes
- Build an apparent photocenter motion model for each type of source
  - Couple models with narrow and wide angle observational modes to assess the ability of SIM to determine accurate and precise orbital parameters
  - Use Monte Carlo simulations to quantify the ability of SIM to isolate the photocenter motion of each of the components and determine which of the orbital and system parameters significantly affect the observations
- Build a recommended SIM target list
  - For each source, assign a required astrometric precision and a required SIM observational time
  - Determine minimum amounts of wavelength binning needed to produce sufficient S/N and a sufficient number of samples to create a curve of growth for each system

Summary

- Potential number of sources
  - 15 BH systems + 13 NS systems + ~275 magnetic and non-magnetic CVs (99 DN, 153 Novalikes, 18 Classical Novae, 5 supersoft, recurrent novae; no AM CVn's) ≈ 303 systems
- Photocenter contamination is an issue that *affects all interacting binaries*, including those already selected by SIM for study.
- By investigating many systems in each interacting binary class, spanning the entire range of primary component masses, this study will allow us to:
  - Quantify the effect of contamination on photocenter determination
  - Devise observation scheme to extract orbital parameters
  - Determine masses of each of the components in the interacting binary