The MIRC-X and BIFROST binary survey: Fundamental Stellar Parameters & Star Formation

Stefan Kraus (Exeter)

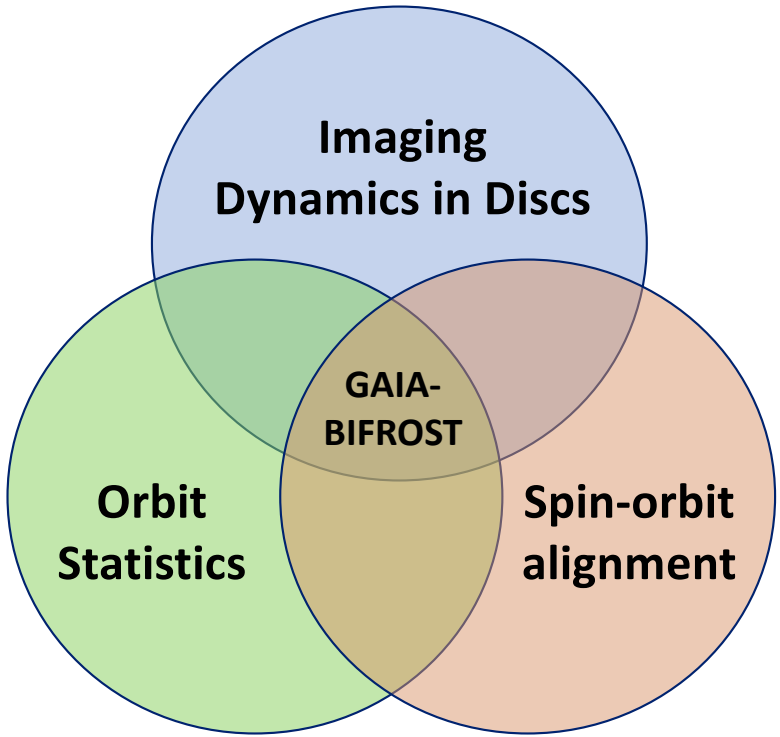
MIRC-X team: **John Monnier,** Ben Setterholm, Tyler Gardner, Jacob Ennis, Noura Ibrahim (Michigan), Alex Kreplin, Aaron Labdon, Claire Davies, Isabelle Codron (Exeter), Narsi Anugu (Arizona), Jean-Baptiste LeBouquin (IPAG), Cyprien Lanthermann (CHARA)

VLTI visitor instrument collaborators: **Michael Ireland,** Luca Casagrande (ANU), Frantz Martinache (Nice), Barnaby Norris (Sydney), Denis Defrere (Liege), …

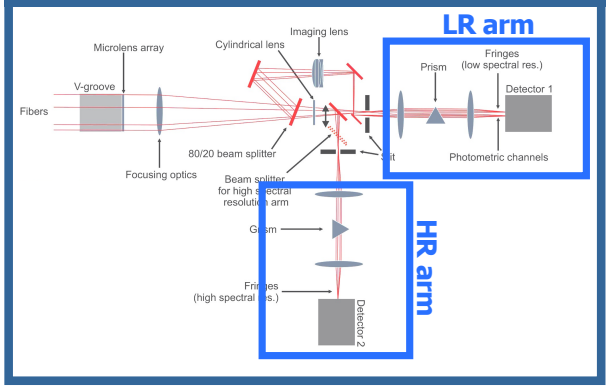
Dynamical processes shaping the architecture of stars and planetary systems

CHARA/MIRC-X

MIRC-X



VLTI/BIFROST



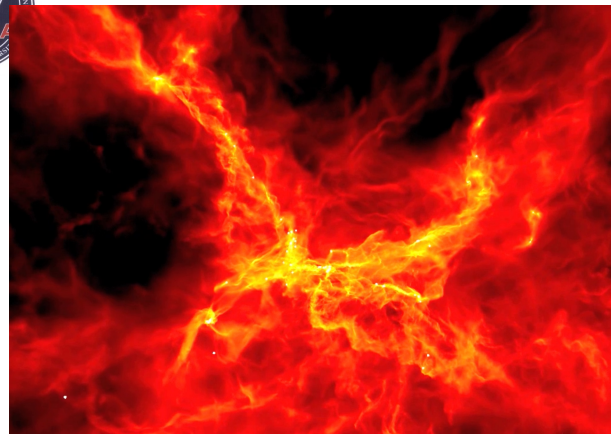
erc

2021-2026

MIRC-X and BIFROST binary survey

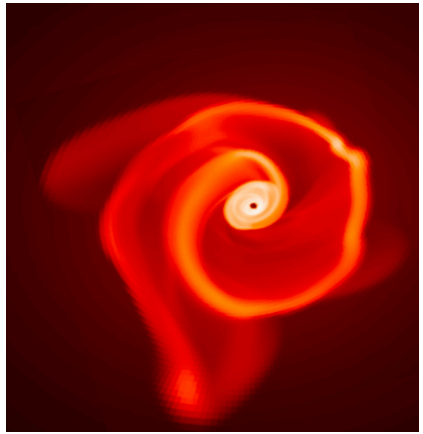
Georgia State University · NSF · NOIR Lab · l'Observatoire de Paris · LESIA · Observatoire de la Côte d'Azur · The University of Sydney · Australian National University · 京都大学 Kyoto University · University of Exeter

Formation scenarios for **WIDE** binaries



CLOUD fragmentation

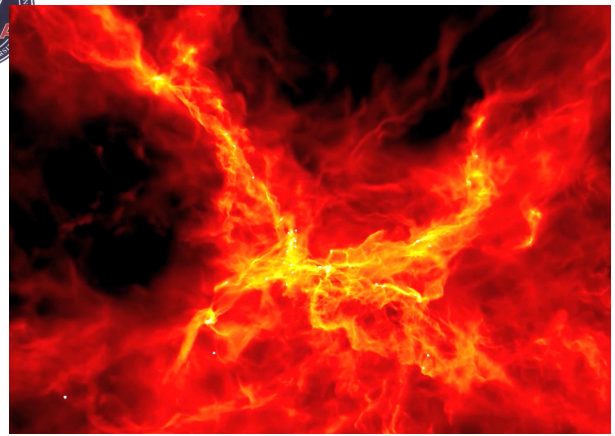
1000…10,000 AU



DISK fragmentation

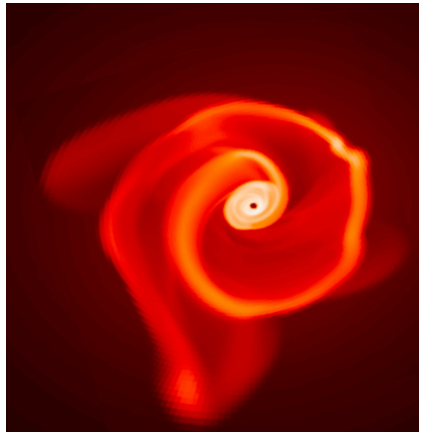
30…300 AU

Formation scenarios for WIDE binaries



CLOUD fragmentation

1000…10,000 AU



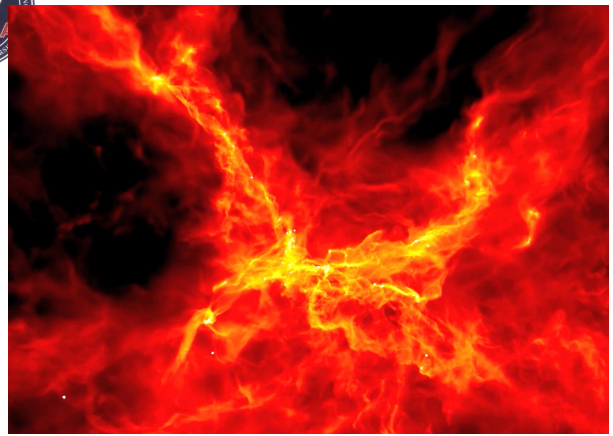
DISK fragmentation

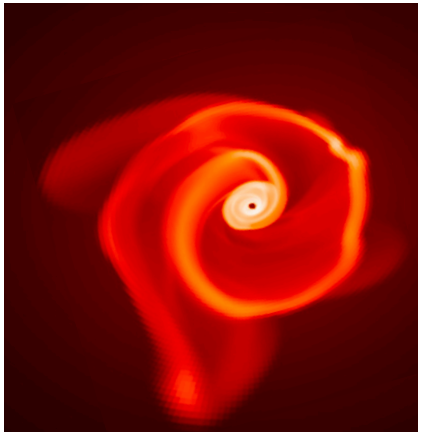
30…300 AU

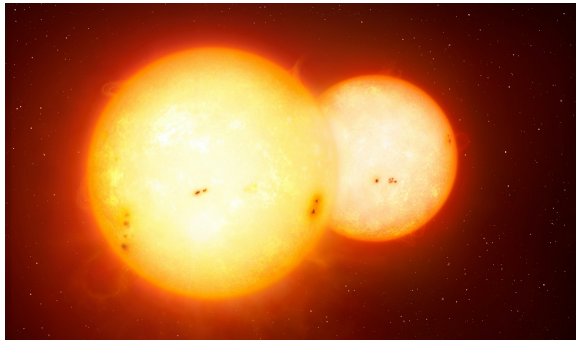
Randomly distributed

Spin-Spin alignment:

aligned







CLOUD fragmentation

1000…10,000 AU

DISK fragmentation

30…300 AU

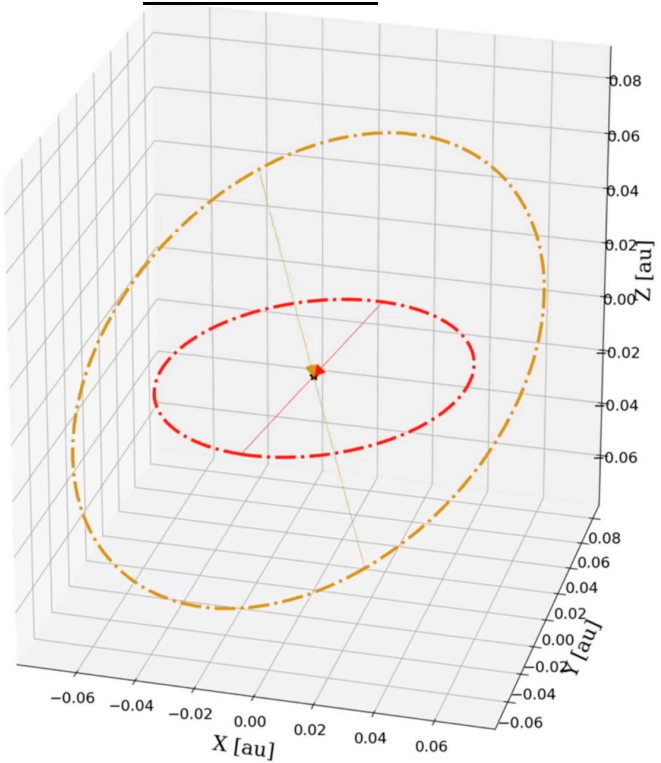
Close binaries

0.1 AU

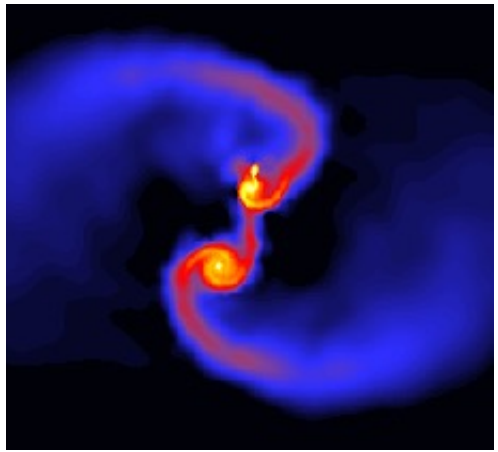
???

Binary system architecture

Kozai-Lidov



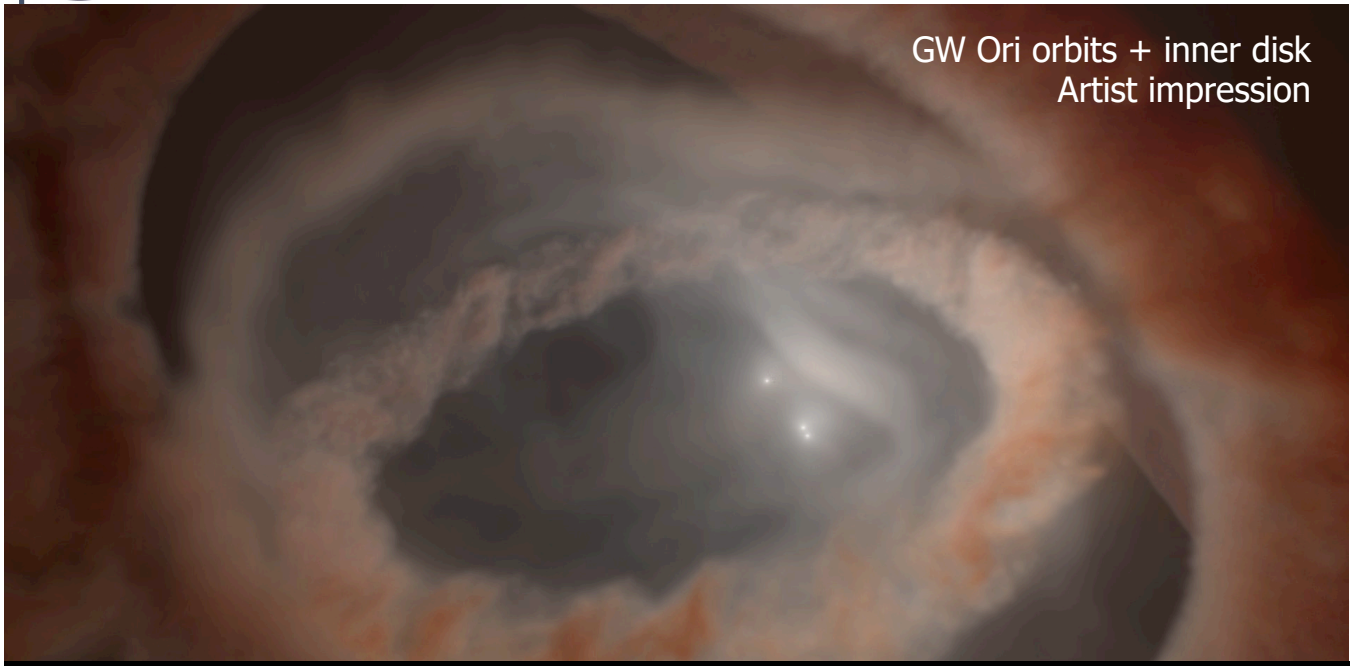
Hydrodynamic interactions

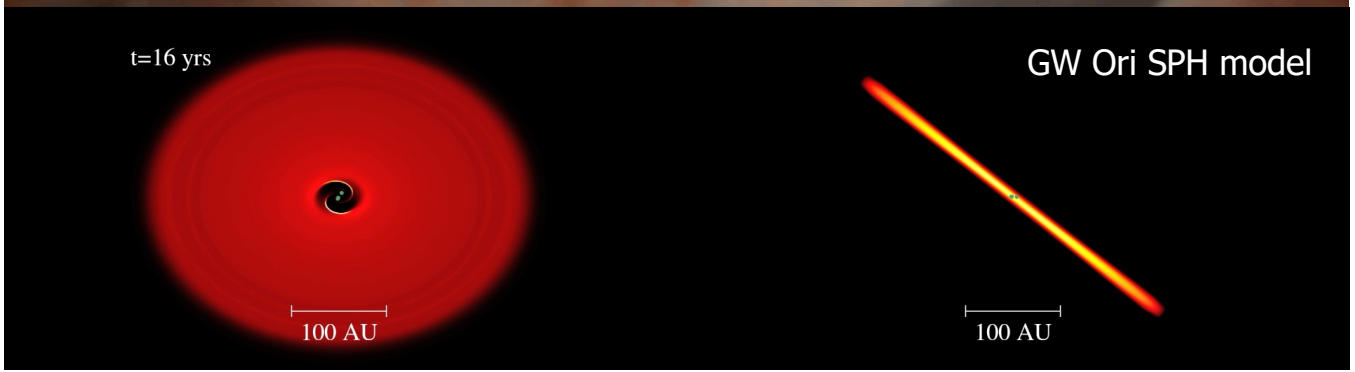


Spin-Orbit alignment traces post-formation evolution

Livingston; Bate+ 1995

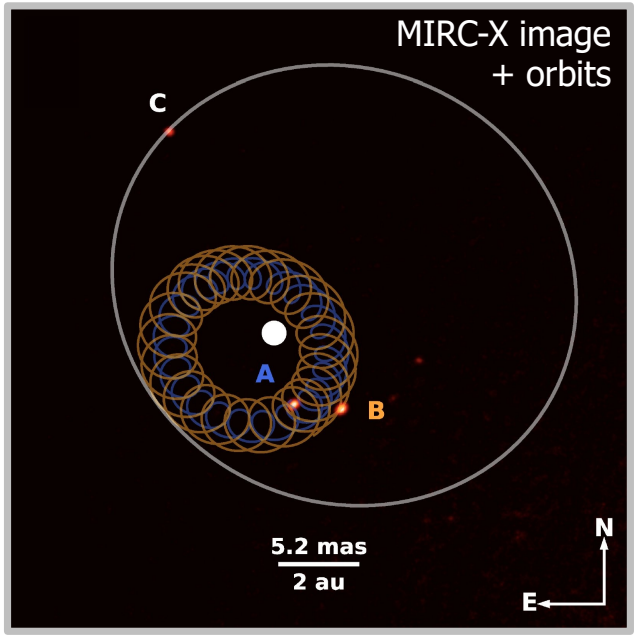
Imaging dynamical processes in disks





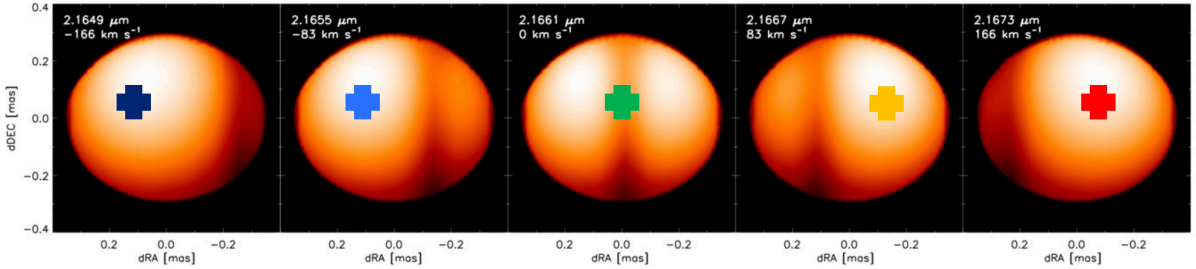
Determine initial conditions of binary and planet formation

Study dynamical perturbations in well-characterized systems



ESO/Calcada, Kraus+ 2020

Spin-orbit alignment

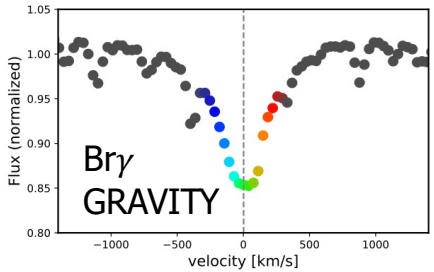


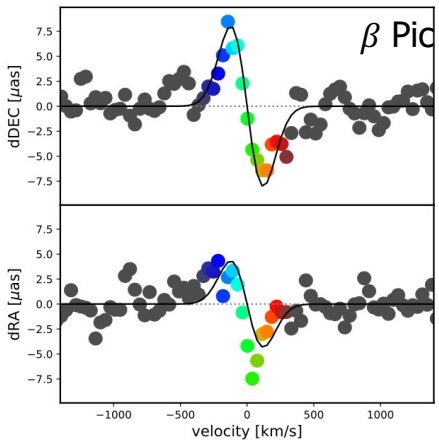
Measure photocenter displacement in photospheric absorption line

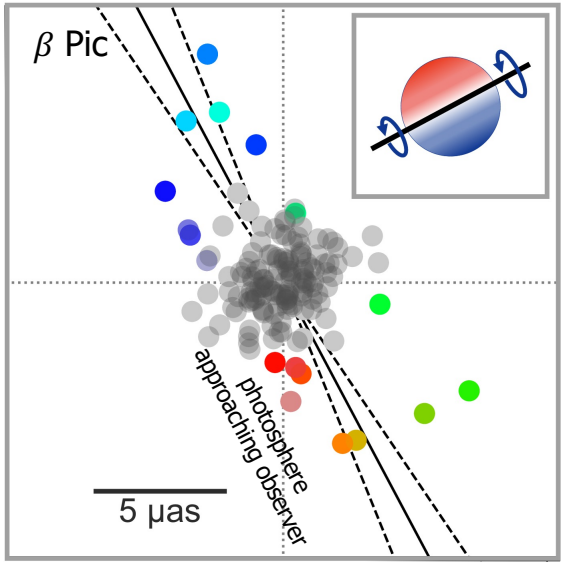
➜ **Tight constraints on sky-projected spin-axis orientation**

Survey:

Spin-orbit alignments for large sample of binaries and planet host stars







β Pic: 3-D obliquity angle 3±5°

➜ **Spin / planet orbit / debris disk well aligned**

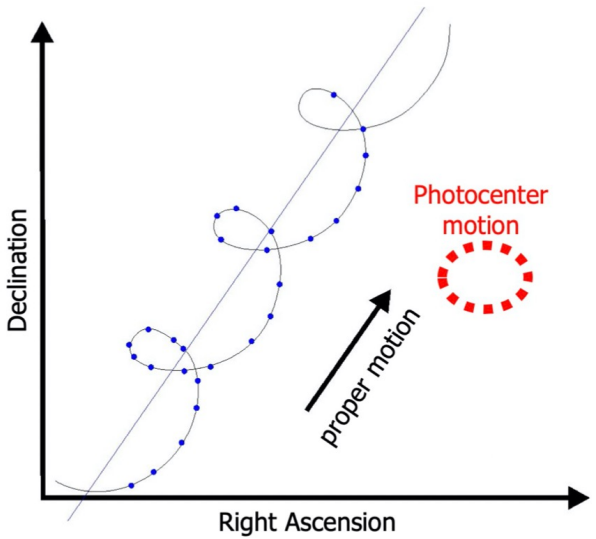
Kraus+ 2012, 2020b

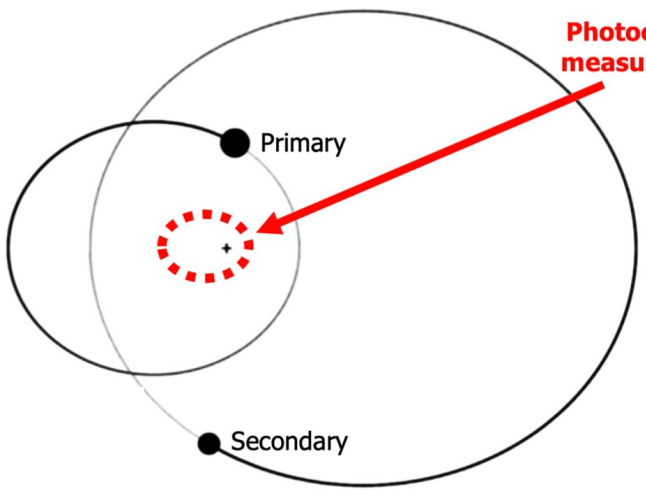
MIRC-X and BIFROST binary survey

Flux-ratio/separation degeneracy for GAIA binaries

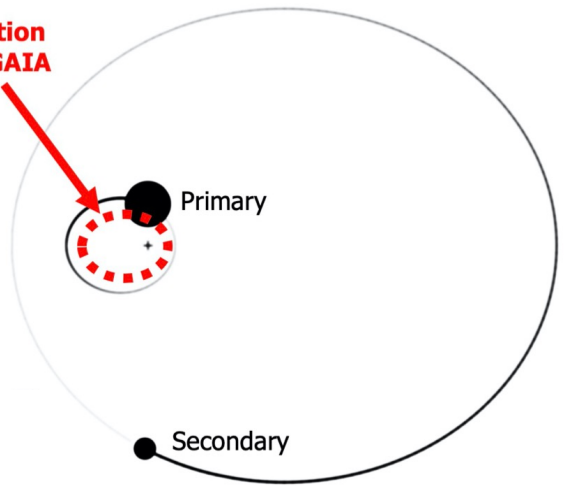
GAIA will provide a census of stellar multiplicity in solar neighborhood (astrometric accuracy ~10 μas)

Photocenter 'orbits' face stellar flux ratio / separation degeneracy
➜ Incomplete orbital parameters; no dynamical masses for non-eclipsing systems





low-flux-ratio / wide separation



high-flux-ratio / small separation

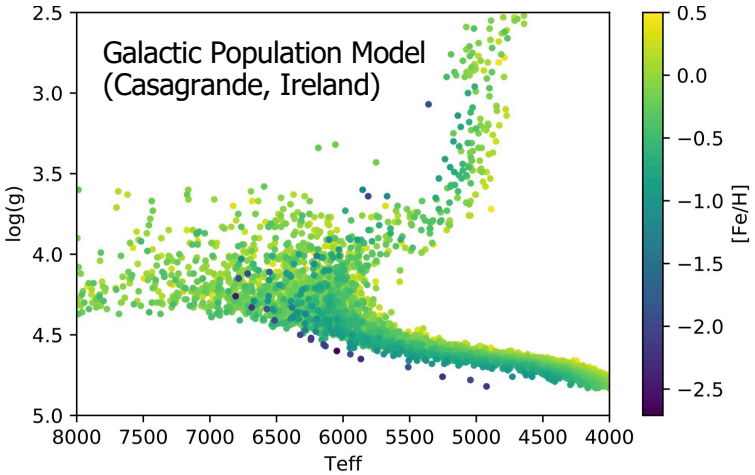
Orbital Architecture & Fundamental Stellar Parameters

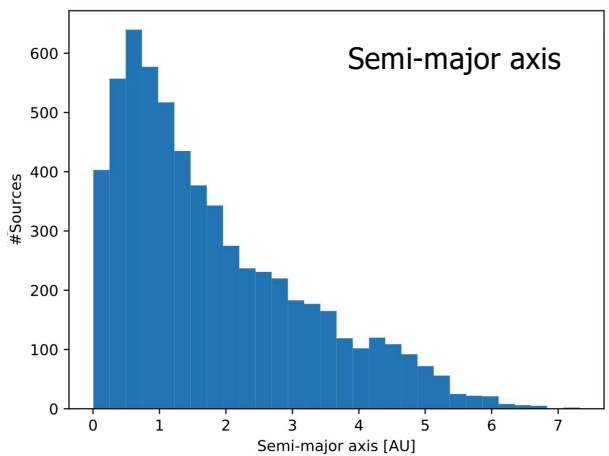
Orbital Statistics:

- Separations of few AUs fills gap between RV/eclipsing systems and wide AO binaries
- Search for bimodal distribution that could correspond to cloud fragmentation / disk fragmentation

Dynamical masses:

- Gold standard for calibrating evolutionary models
- Very pristine, non-interacting systems
- Prioritize most **rare stellar populations**, e.g.
  - Low-mass stars (Baraffe+ 2014)
  - Massive stars: overshooting, mass loss (Constantino+ 2018)
  - Low metallicity stars
  - Pre-main-sequence stars (Gallart+ 2005)
  - …

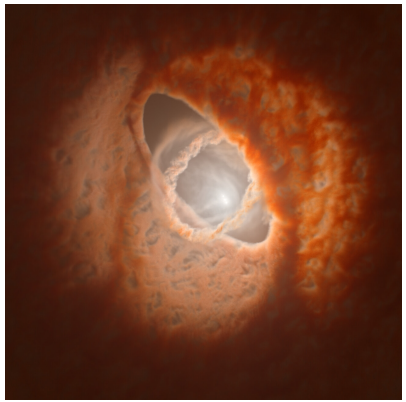




Summary: Fundamental Stellar Astrophysics + Star Formation

Coordinated Northern+Southern hemisphere survey with MIRC-X and BIFROST. Specific CHARA objectives are:

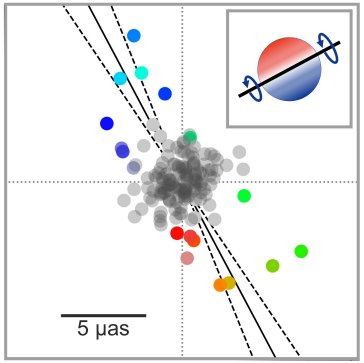
Imaging disks + companion-disk interactions



MIRC-X:

- Constrain initial conditions of planet+binary formation
- Accretion in young binaries

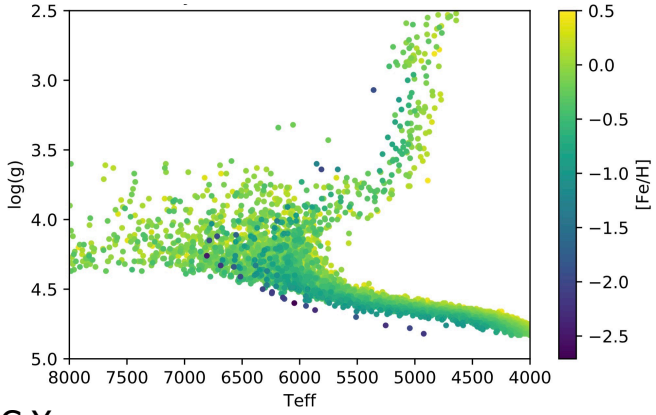
Spin-orbit/spin-spin alignment of binaries and planet hosts



MIRC-X, SPICA:

- Install filterwheel (already @UM)
- Consider purchase of higher-dispersion MIRC-X grism
- Sample size will depend strongly on fringe tracking performance

Orbit statistics + Dynamical masses (and ages)



MIRC-X:

- Hundreds of binaries over whole HRD diagram
- Fully commission J-band
- Potentially of interest for broad CHARA community
- Plan to build working groups for different object classes for target selection & interpretation