TEXAS TECH UNIVERSITY™

UVEX and LISA

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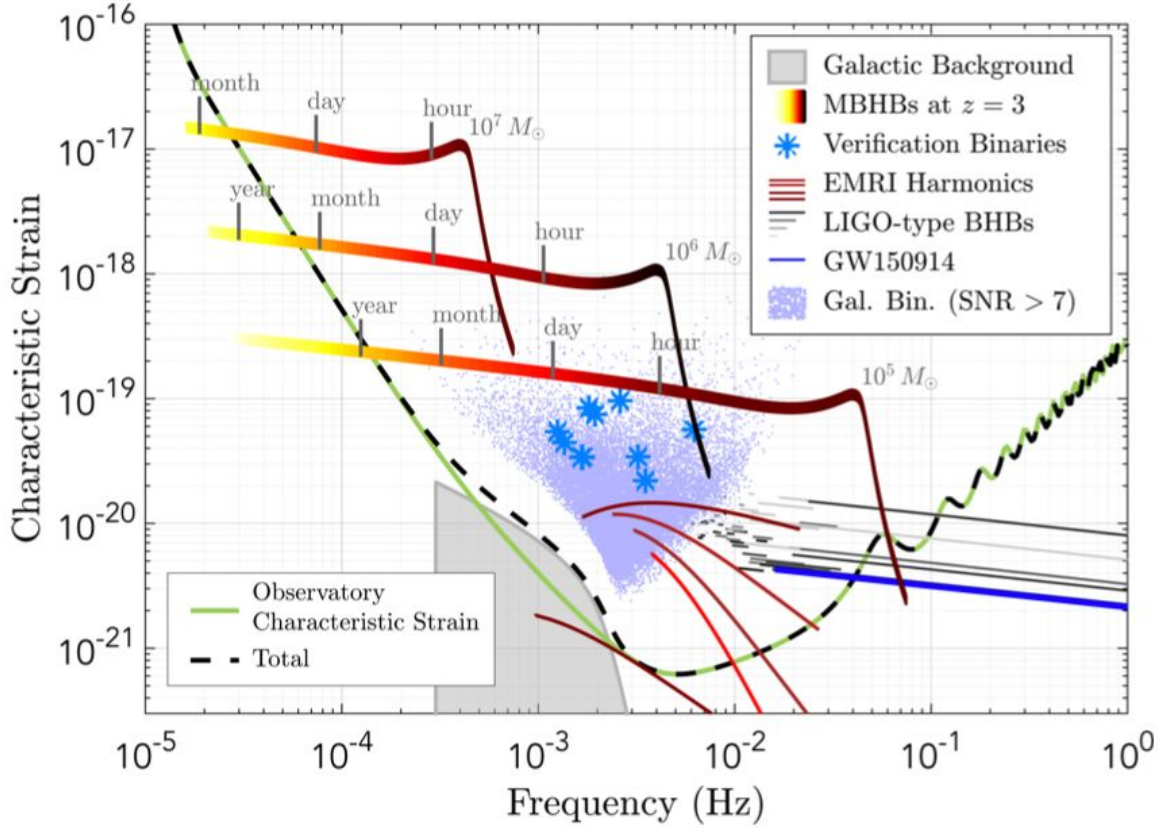
With thanks to many colleagues, especially Thomas Kupfer (TTU), Liliana Rivera Sandoval (UTRGV) and Manuel Pichardo Marcano (AMNH) for useful discussions over the years

Overview

- LISA: what kinds of things can it observe and when
- Why UV matches well to some LISA capabilities
- What operations plan changes are needed for UVEX to best support LISA
- *My focus will be on aspects not covered in the Galactic Plane Survey, especially globular cluster ultracompacts*

LISA



Cornish, Robson & Lu (2018)

Planned launch: 2037?, no formal timeline overlap

Either LISA launch moved up, UVEX extended, or UVEX does only preparatory science

Source classes

Merging supermassive black holes

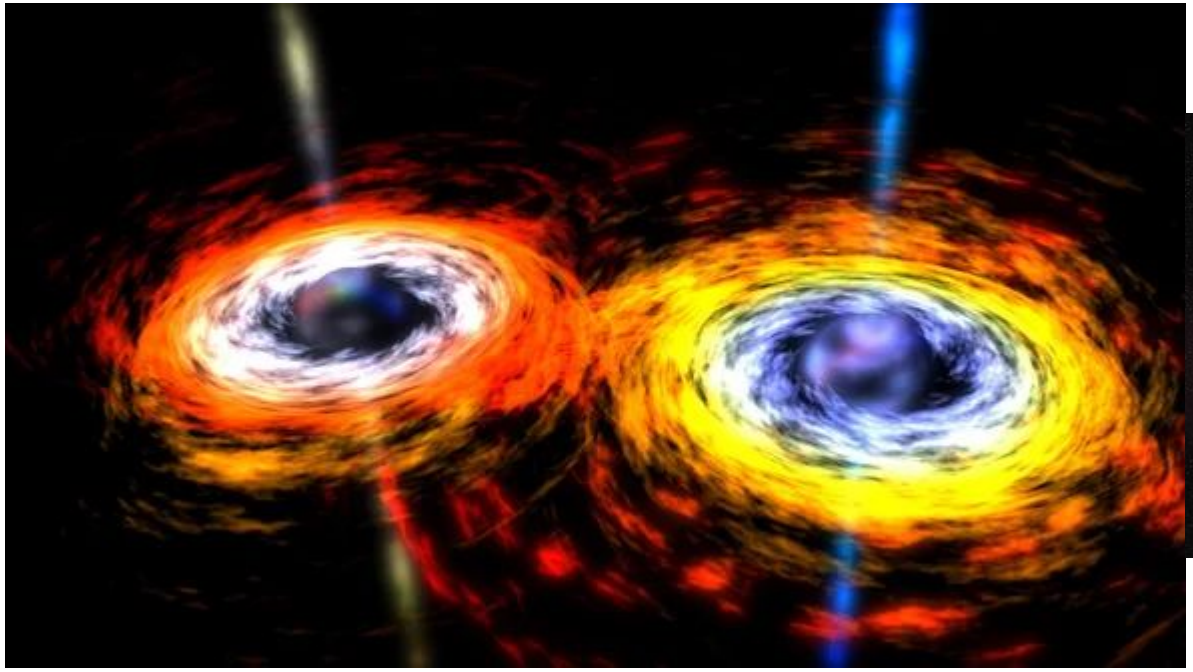
Extreme mass ratio inspirals

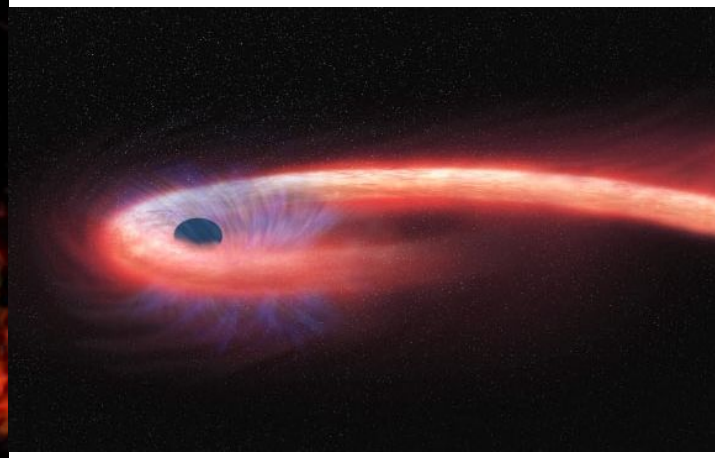
Double white dwarfs/He star-WD binaries

WD/He star + neutron star

WD/He star + black hole

Supermassive black holes

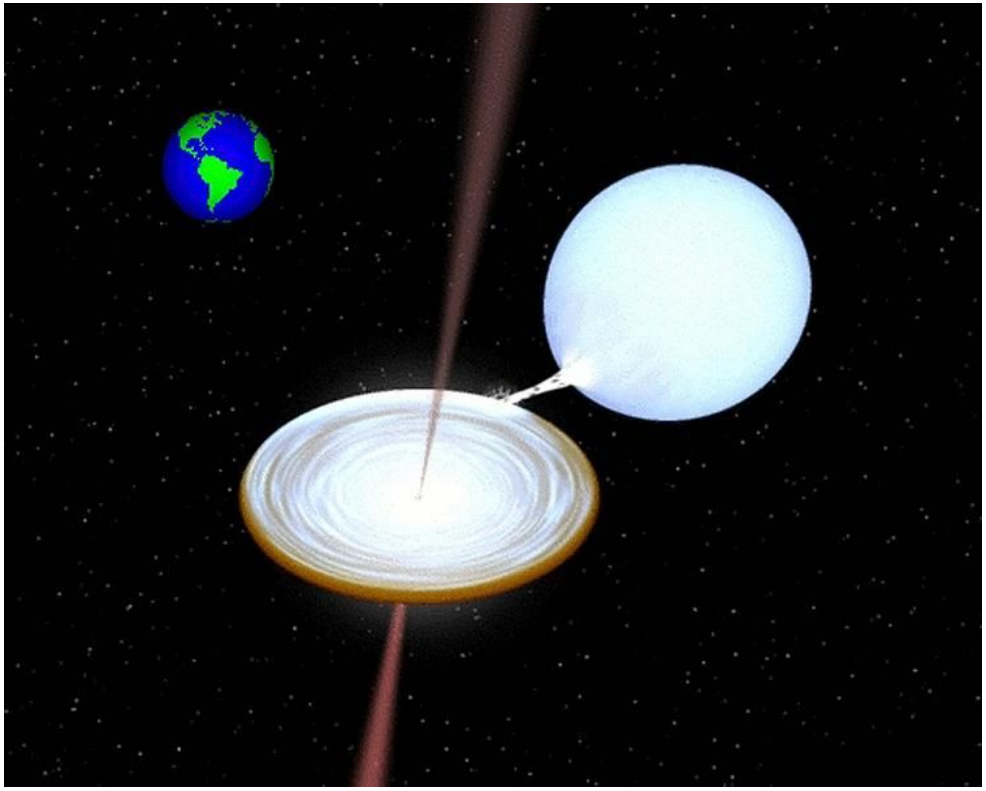


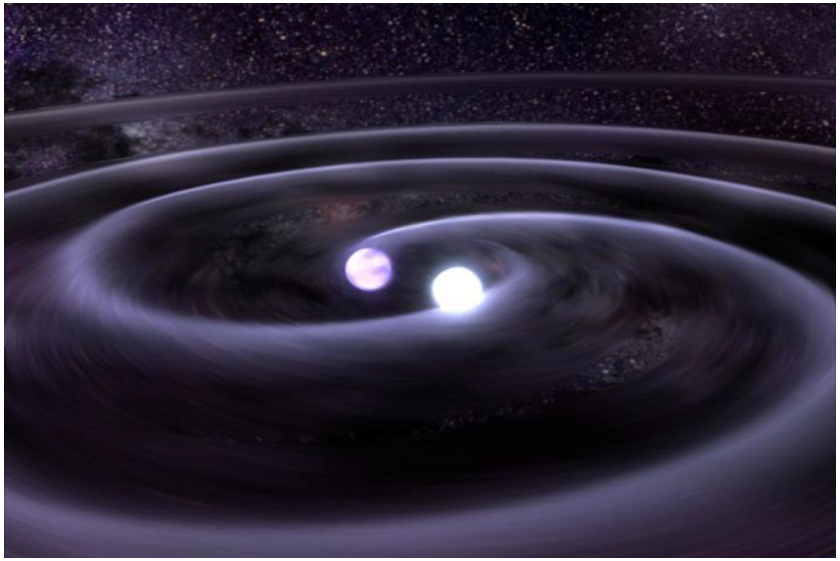


- Probably better studied at other wavelengths
- May be embedded in dust
- Attempts to find close-in binary quasars beforehand are plagued by red noise, and great care, with very large data sets, is needed to find periods

- Some extreme mass ratio inspirals will be TDEs
- Quasi-periodic ejections may be in this class
- These will necessarily be complicated in terms of GWR signature

Stellar mass compact binaries





Goals: find new verification binaries
Evaluate system parameters better for these objects
Understand the astrophysics of the classes of objects in ways that can help interpret LISA data

Mechanisms to find binaries

- Eclipses - need two WDs or an accretion disk
- Ellipsoidal - distorted companion stars
- Reflection - heated inner faces of close binaries
- Doppler - some LISA sources can have v_orb~0.01 c
  - Effect is ~(1-v/c)^3, and stronger on Wien tail
- Accretion - stochastic variability, outbursts possible

Detached double white dwarfs

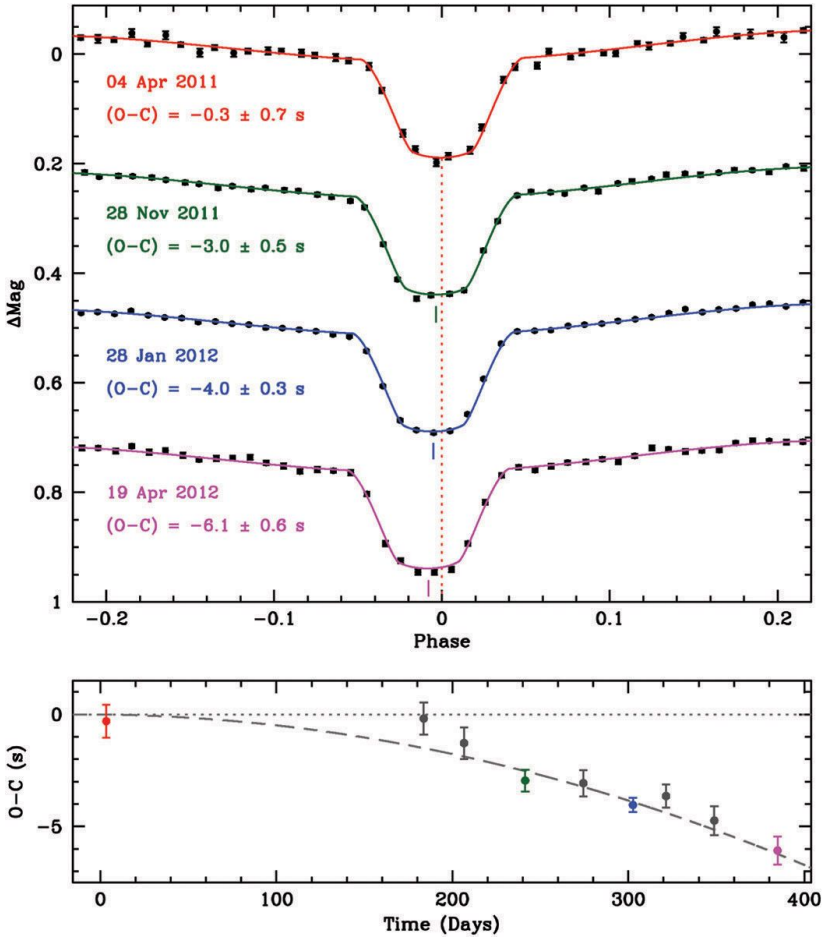
The largest class of LISA sources

Eclipses, accretion, unusual location in CMD (if parallaxes exist)

Would need dedicated observations to find the time variability signature

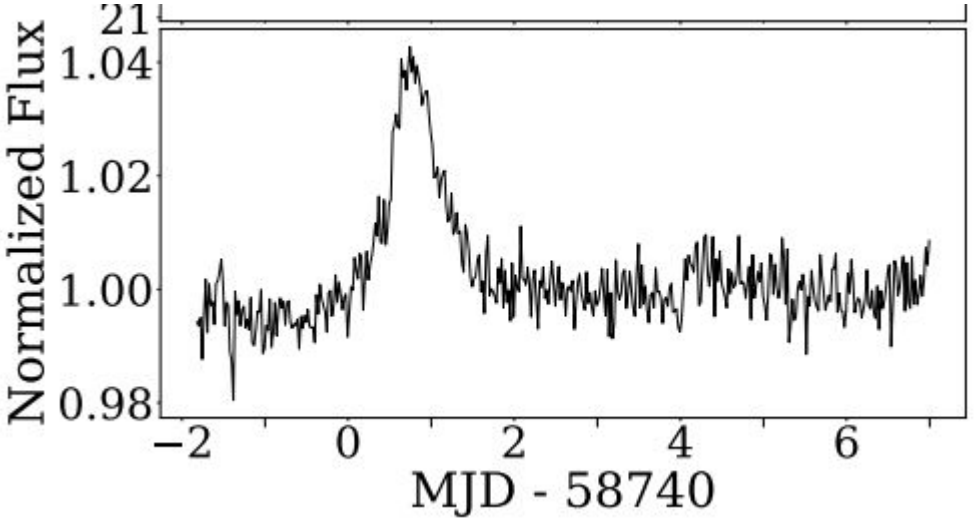
Longer and higher cadence!

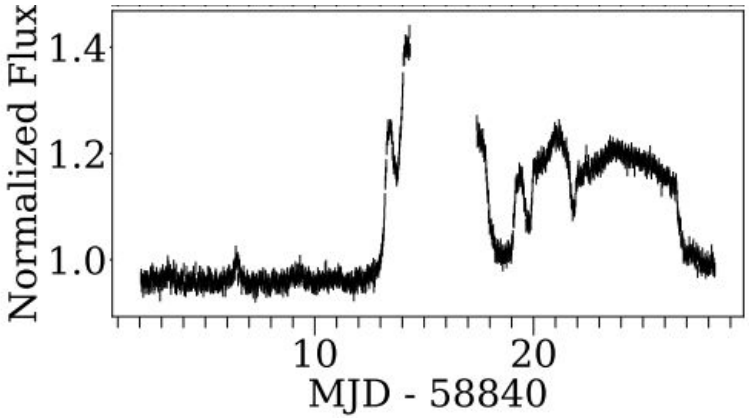
Eclipses can be << P_orb

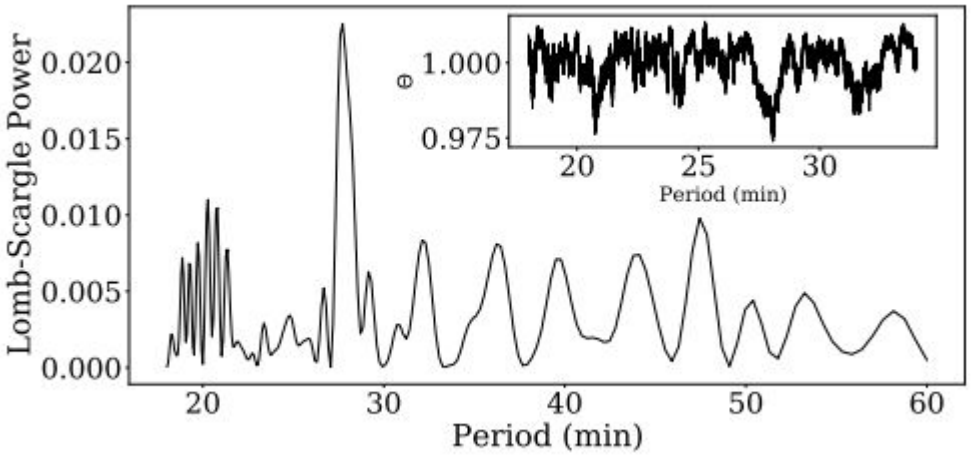


Hermes et al. 2012; period=12.75 min, eclipse duration about 1.5 min

Mass transferring double white dwarfs: the TESS AM CVn Outburst Survey (TACOS)







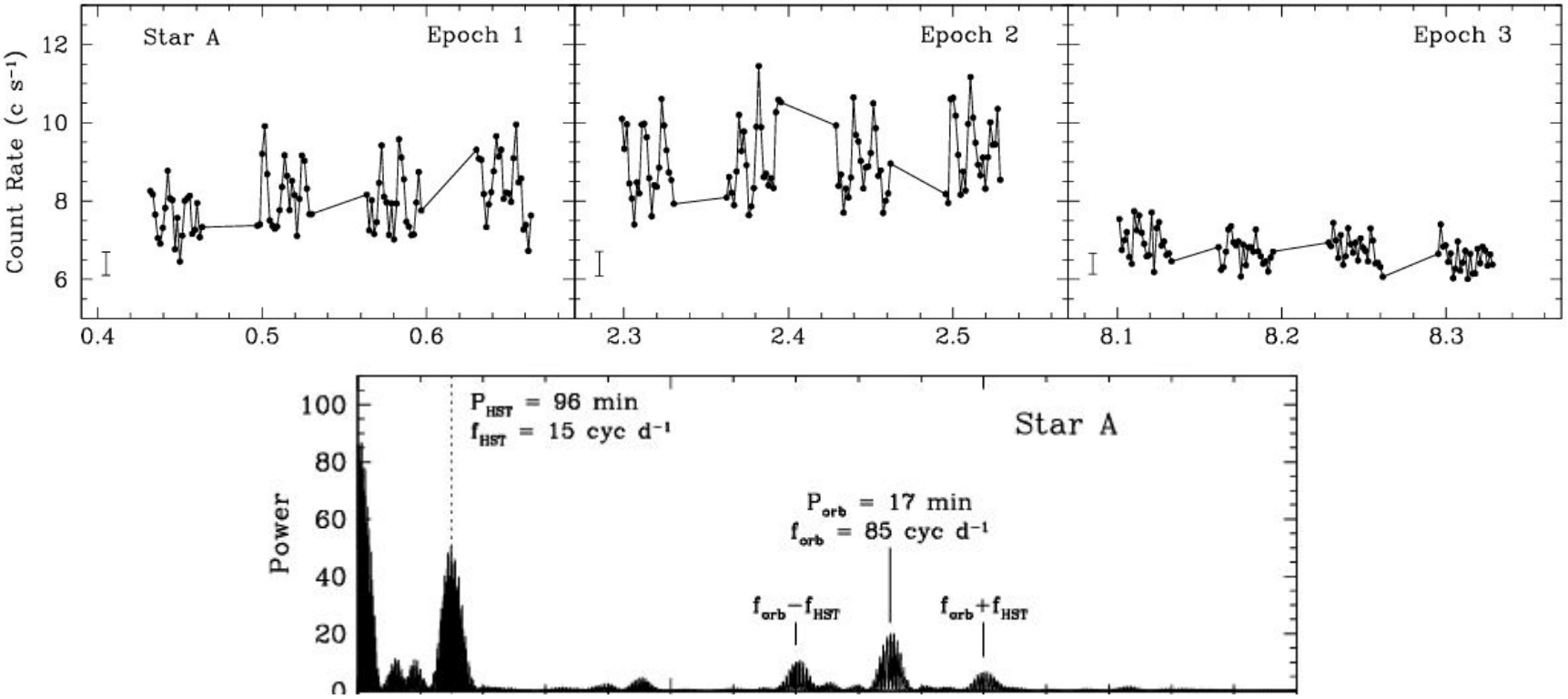
From Pichardo Marcano, Rivera Sandoval, TJM, et al. 2021

Many AM CVn in clusters should be straightforward to find with intensive monitoring;

Sparse monitoring is hard to make use of because it cannot find the “normal” outbursts

AM CVn typical peak at M_V~7, and have UV-V~-2; recurrence times and duty cycles strong functions of orbital period

X-ray binaries



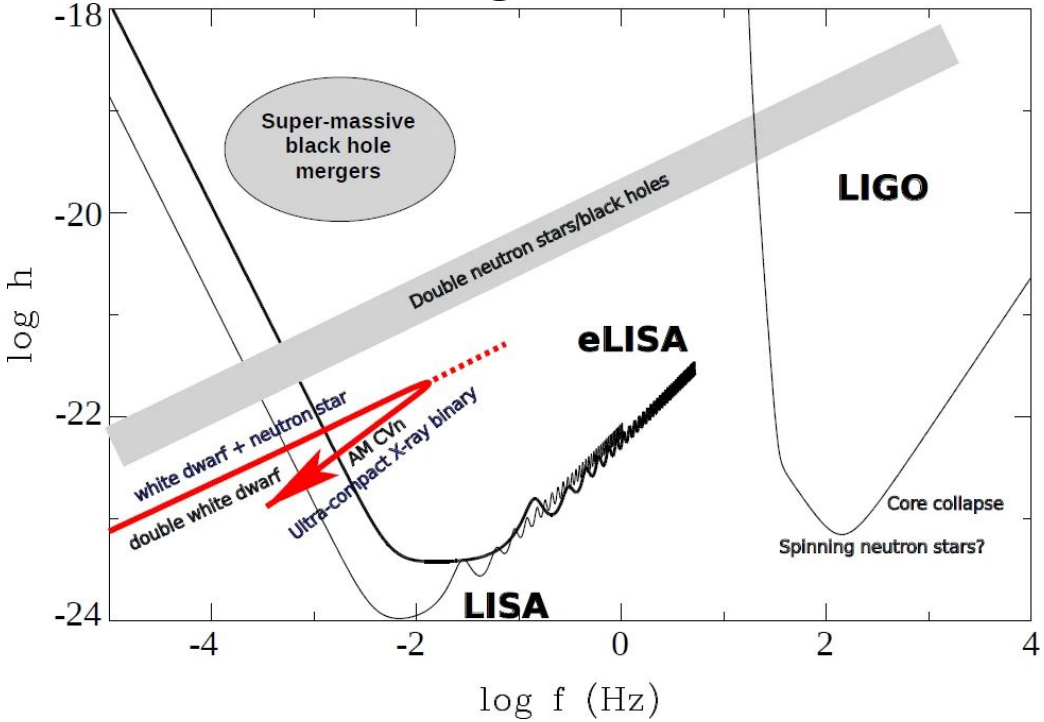
NGC 1851 UCXB, from Zurek et al., 2009

Modulation due to reflection effect, does not show up in optical

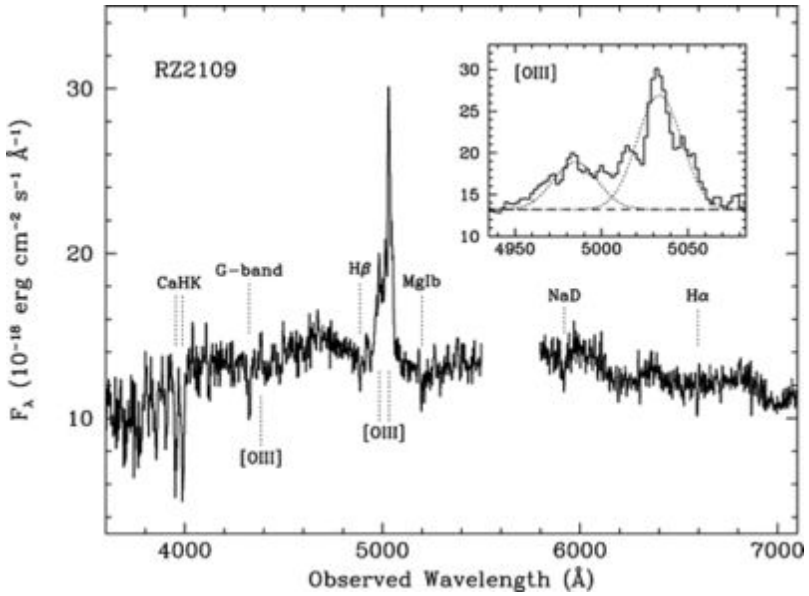
Aliasing due to HST orbit is severe

Pre-X-ray binaries

These are the brightest LISA sources!



Some UCXBs have CO donors!



Zepf, TJM, et al., 2008

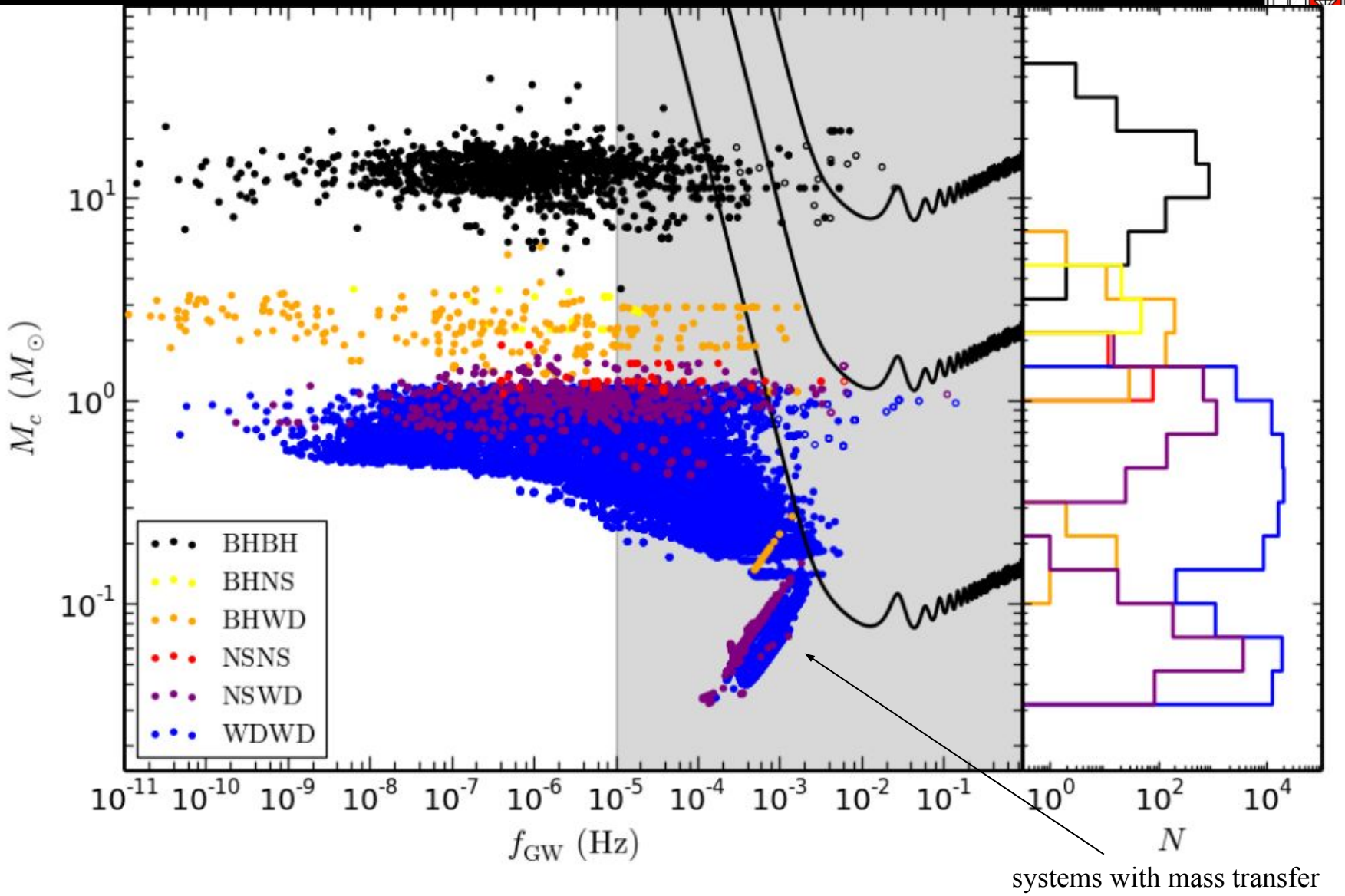
See also Miller-Jones et al. 2015, Koliopanos et al. 2020

Postnov & Yungelson 2014

No accretion, no eclipses, good UV light curves may help, especially in globular clusters!

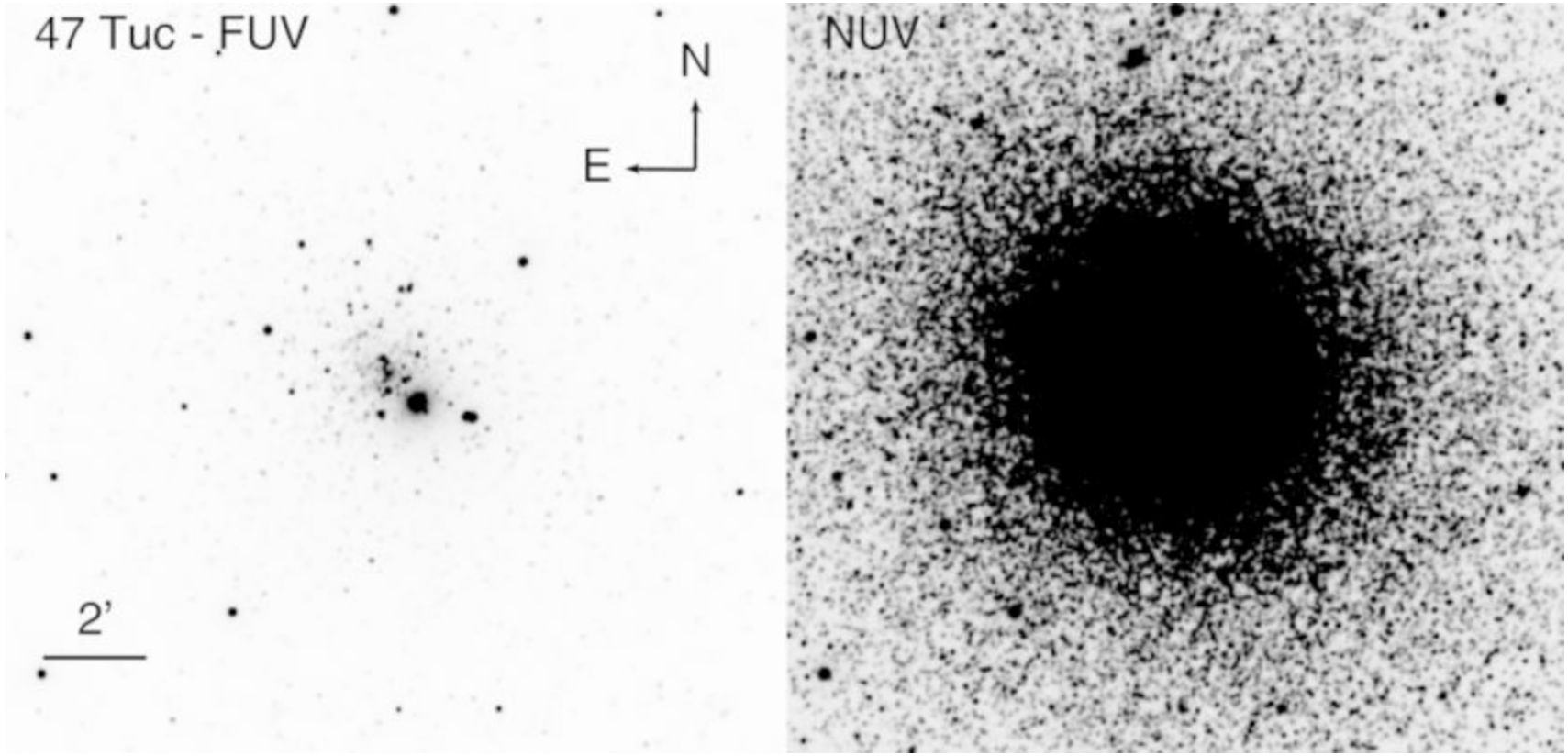
Best cases may show doppler modulation

Globular clusters should have LISA sources



Kremer et al. 2018; open symbols are highly eccentric binaries

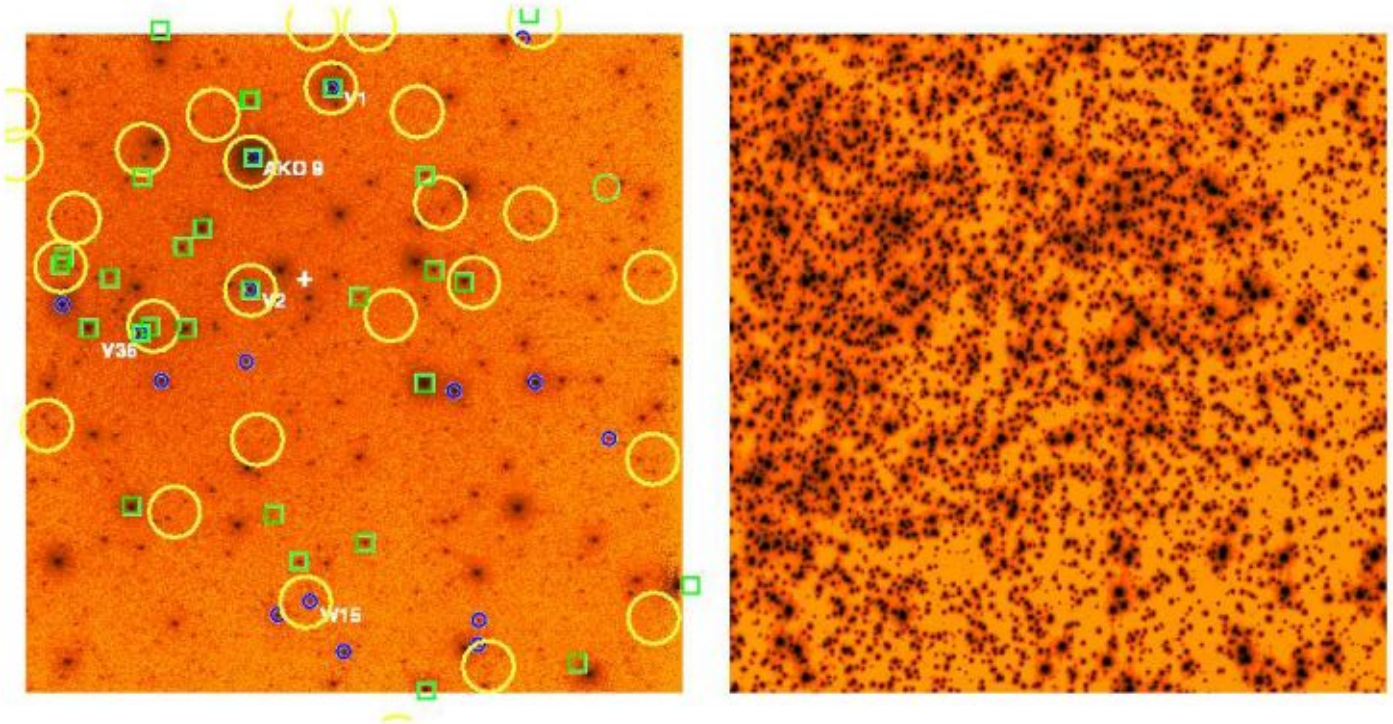
Crowding in clusters



2” is not ideal for globular clusters, but tolerable, especially in search for periodicities

Fig from Schivaon et al. 2012

Globular clusters



47 Tuc, HST, 25” square, ~15000 second with STIS FUV on source, Knigge et al. 2002. (Right side is U band). Circles are roughly 2”

Necessary capabilities not in the baseline plan, but within hardware capabilities

- Long observations (avoid aliasing, red noise, increase frequency resolution)
- Better than 6 minute time resolution (that's not even Nyquist sampled for some key objects
- ***Long looks at globular clusters with higher time resolution may be fruitful. Can these be the calibration sources?***
  - ***Background from faint stars will make read noise less of the noise budget***

Celebrity endorsement for faster cadence