MNRAS **000**, 1–1 (2020) Preprint 13 April 2020 Compiled using MNRAS LaTeX style file v3.0

GW-EM LISA Notes

Accepted XXX. Received YYY; in original form ZZZ

ABSTRACT

Key words: (stars:) white dwarfs – (stars:) binaries: eclipsing

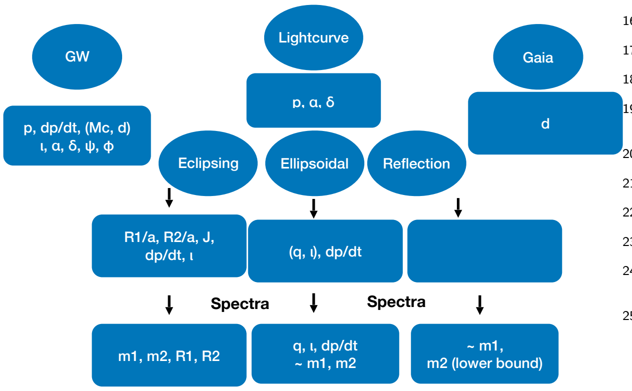

Figure 1. Flow chart.

1 NOTES

1.1 Lightcurve analysis

- Short-orbital period + general relativity means that binaries undergo rapid orbital decay due to the emission of gravitational radiation
- We can use optical timing instruments to constrain the eclipse times ($\sigma_T \sim 0.5$ s) (also longer time-scale measurements from PS1 or ZTF or whatever)
- Use these eclipse times to measure a changing orbital period.
- O-C diagram yields a deviation growing quadratically in time.

Equation 1

$$\Delta t_{eclipse}(t-t_0) = \left(\frac{1}{2}\dot{f}(t_0)(t-t_0)^2+\frac{1}{6}\ddot{f}(t_0)(t-t_0)^3+...\right)P(t_0) \quad (1)$$

where t_0 is the reference epoch, $P(t_0)$ is the orbital period at the reference epoch, $f(t_0)$, $\dot{f}(t_0)$, etc, are the orbital frequency and its time derivatives at the reference epoch, and $t - t_0$ is the time since the reference epoch.

Workflow

- Maria: Create a P and a T_0 for every set of observations based on a fiducial $\ddot{f}$ and P_0; want to eventually choose a chirp mass
- Greg: posteriors on P and T_0 for every night of observations
- To be done: script to combine posteriors to fit for $\ddot{f}$

Light curves are generated using the `ellc` package (Maxted 2016), which depends on the mid-eclipse time of the primary eclipse, t_0, the inclination, ι, the mass ratio, $q = \frac{m_2}{m_1}$, the ratio of the radii to the semi-major axis, $r_1 = R_1/a$, $r_2 = R_2/a$, and the surface brightness ratio, J.

- Merger time-scale: $\tau_c = \frac{3}{8}\frac{P}{|\dot{P}|}$

1.2 Gravitational-wave analysis

From LISA, we can get f_{GW}, $\dot{f}_{GW}$, amplitude of the GW strain, inclination ι, gravitational-wave polarization angle ψ and rotation angle ϕ. From the GW strain, we measure chirp mass and distance:

- $Mc = \left(\dot{f}_{GW} \times f_{GW}^{-11/3} \times \frac{5}{96} \times \pi^{-8/3}\right)^{3/5}$
- $D_l = \frac{5}{48}\left(\frac{\dot{f}_{GW}}{\pi^2 \times f_{GW}^3 \times A}\right)$

- Tides from the white dwarf binaries also affect the energy of the systems, which takes away additional energy from the binary, and therefore the purely gravitational-wave losses are less!
- Want to compare the optically measured number to those from LISA

1.3 Combined analysis

Portions of this work were performed during the CCA LISA Sprint, supported by the Simons Foundation

REFERENCES

Maxted P., 2016, Astronomy & Astrophysics, 591, A111

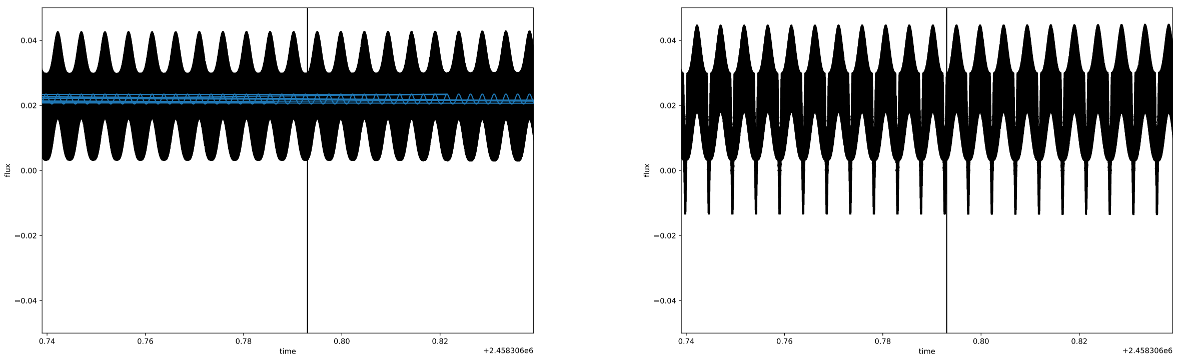

Figure 2. Light curves for a purely ellipsoidal (left) and ellipsoidal and eclipsing (right) systems.

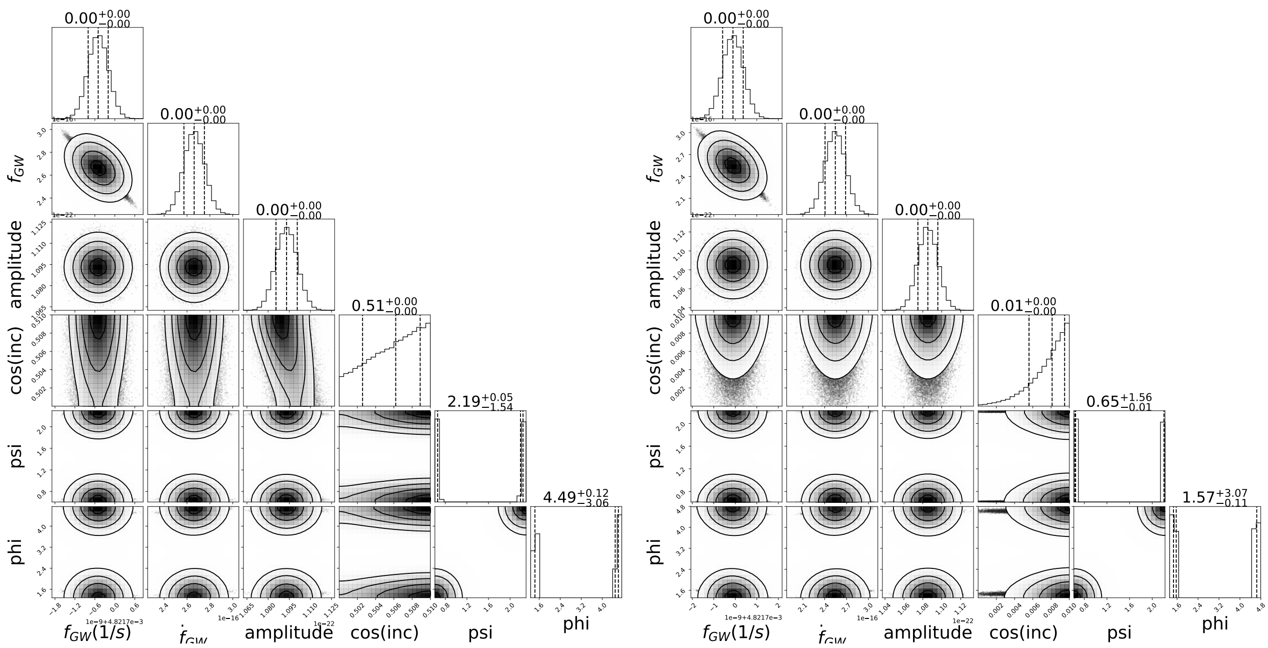

Figure 3. Gravitational wave-based constraints for a purely ellipsoidal (left) and ellipsoidal and eclipsing (right) systems.

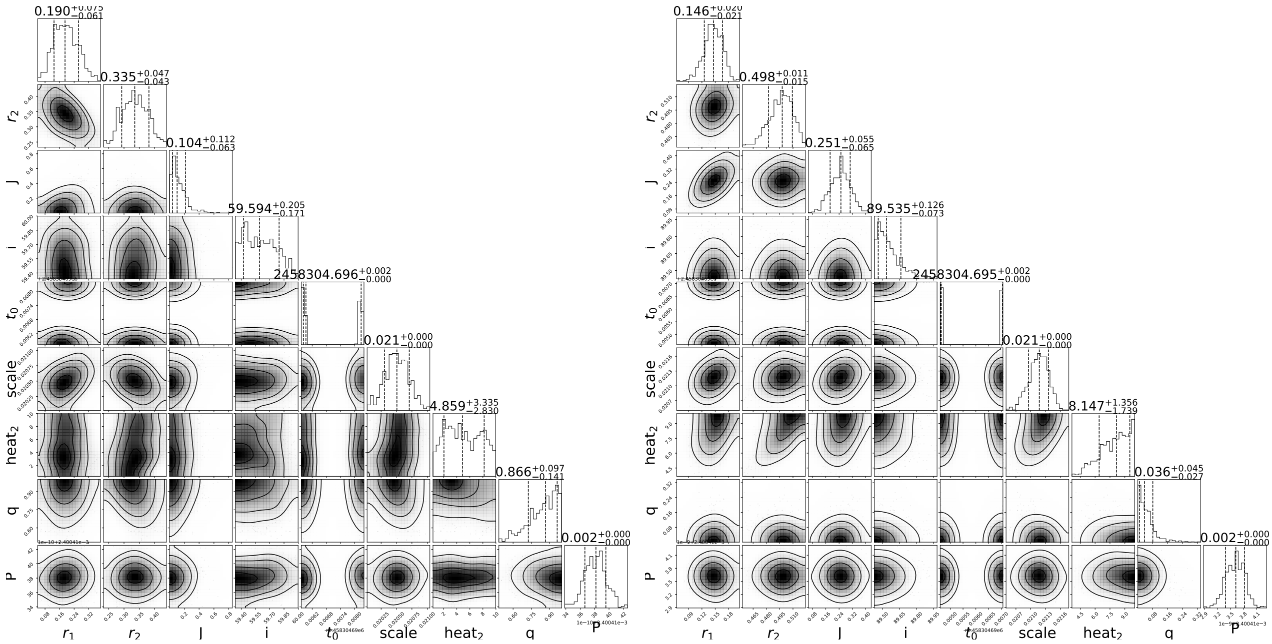

Figure 4. Light curve-based constraints for a purely ellipsoidal (left) and ellipsoidal and eclipsing (right) systems using the gravitational wave-based constraints as priors for the light curve analysis.