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Astrometric Gravitational-Wave Detection via Stellar Interferometry

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In this talk, I will evaluate the potential for gravitational-wave (GW) detection in the frequency band from 10 nHz to 1 μHz using extremely high-precision astrometry of a small number of stars. In particular, I will argue that non-magnetic, photometrically stable hot white dwarfs (WD) located at $\sim$ kpc distances may be optimal targets for this approach. Previous studies of astrometric GW detection have focused on the potential for less precise surveys of large numbers of stars; this work provides an alternative optimization approach to this problem. Interesting GW sources in this band are expected at characteristic strains around $h_c \sim 10^{-17} \times (\mu\text{Hz}/f_{\text{GW}})$. The astrometric angular precision required to see these sources is $\Delta\theta \sim h_c$ after integrating for a time $T \sim 1/f_{\text{GW}}$. I will show that jitter in the photometric center of WD of this type due to starspots is bounded to be small enough to permit this high-precision, small-N approach. I will also discuss possible noise arising from stellar reflex motion induced by orbiting objects and show how it can be mitigated. The only plausible technology able to achieve the requisite astrometric precision is a space-based stellar interferometer. I will outline how such a future mission with few-meter-scale collecting dishes and baselines of $\mathcal{O}(100\text{km})$ is sufficient to achieve the target precision. This collector size is broadly in line with the collectors proposed for some formation-flown, space-based astrometer or optical synthetic-aperature imaging-array concepts proposed for other science reasons. The proposed baseline is however somewhat larger than the km-scale baselines discussed for those concepts, but there is no fundamental technical obstacle to utilizing such baselines. A mission of this type thus also holds the promise of being one of the few ways to access interesting GW sources in this band.

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