Peter Pan Disks

Long-lived Accretion Disks Around ≥20 Myr Low-Mass Stars

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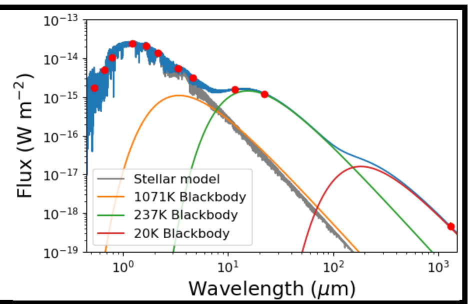
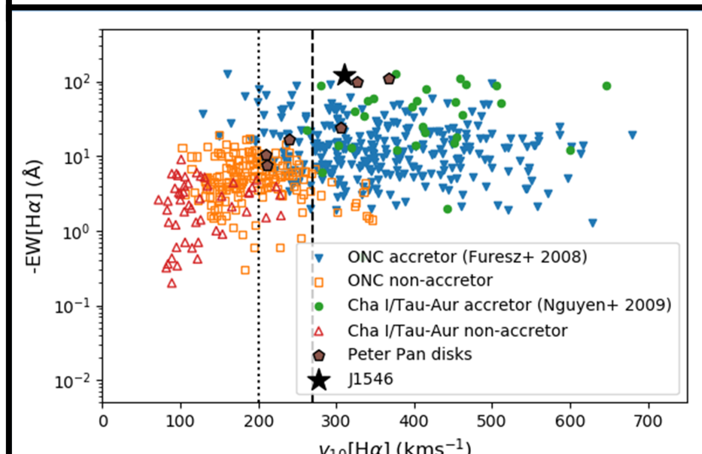
SED of WISEA J080822.18-644357.3, the prototypical Peter Pan disk, using a 3100K stellar model, and 237K, 1071K, and 20K blackbodies for the disk fit. While continuum dust emission is detected at 1.3mm to necessitate a third blackbody component, no CO gas is detected. SED adapted from Flaherty et al. (2019).



This poster summarizes Silverberg et al. (2020) and subsequent new results in the literature regarding "Peter Pan" disks, a class of substantial M star disks with spectroscopic evidence of accretion in young stellar associations (YSAs) at ages ≥20 Myr—i.e. they seem to "never grow up." We outline the ensemble characteristics of the eight known Peter Pan disks from optical and near-IR spectroscopy, ALMA observations of WISEA J080822.18-644357.3 (J0808; the prototypical Peter Pan disk), and optical light curves, including TESS Cycle 3 observations of J0808. We find that these objects most plausibly represent long-lived CO-poor primordial disks, or "hybrid" disks, exhibiting both debris and primordial-disk features. We finally outline Disk Detective v2.0, a citizen science project for identifying circumstellar disks in WISE data that is explicitly designed to leverage *Gaia* to search for new Peter Pan disks.

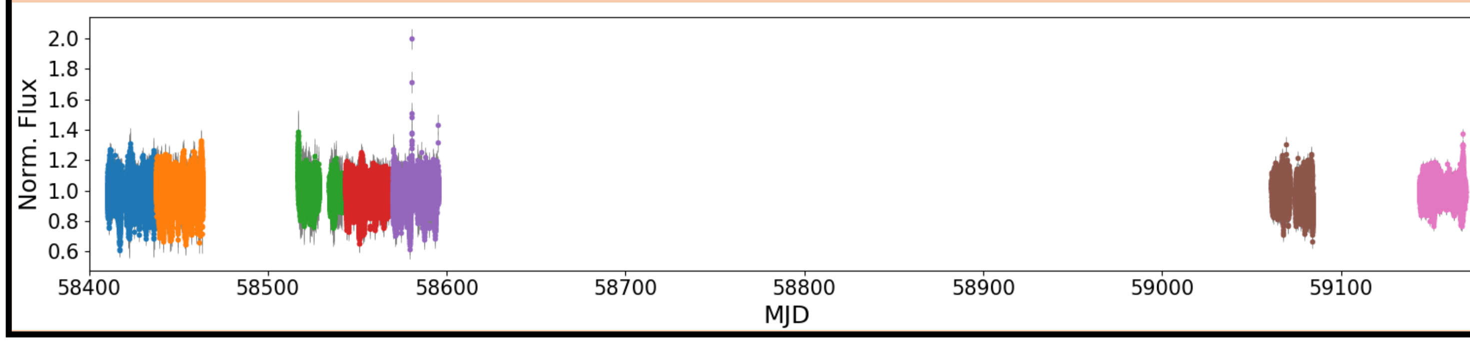
Accretion



Seven Peter Pan disks have recorded optical spectra. Hα emission from these straddles the boundaries separating emission from accretion and stellar activity (e.g. White & Basri 2003), indicating weak accretion. Accreting and non-accreting sources in young associations are shown for reference. Pa β and Br γ emission in near-IR spectra of J0808 indicate accretion rates consistent with the extrapolated rate from younger stars at similar mass.

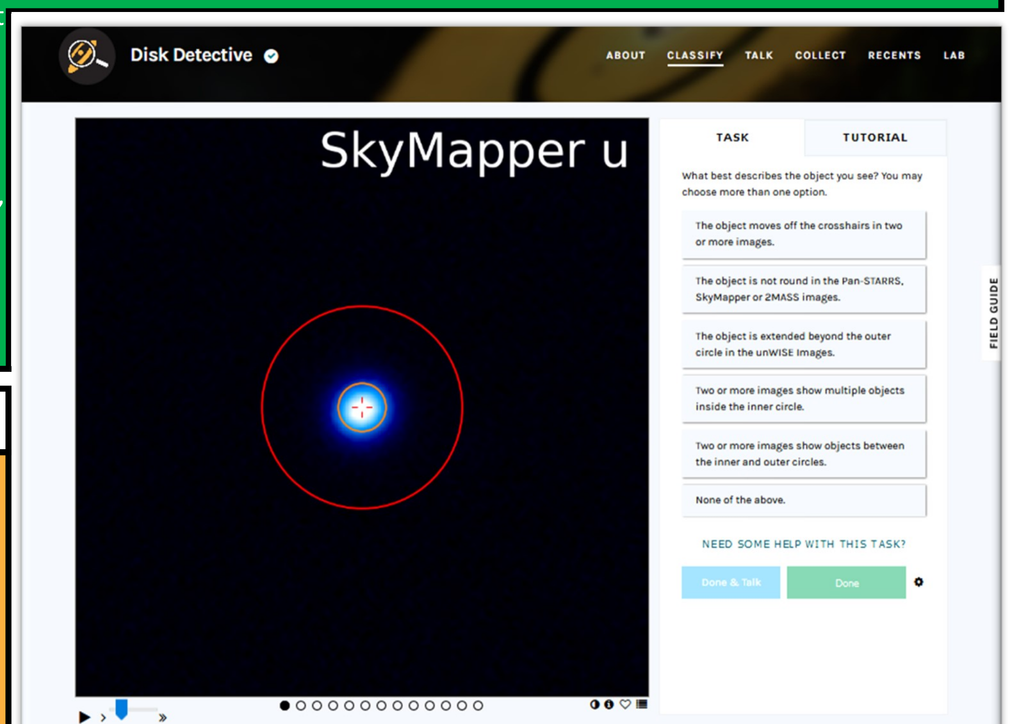
High-Cadence Photometry with TESS

J0808 has now been observed at 2-minute cadence with TESS in Sectors 4-5, 8-10, 28, and 31, providing a multi-year baseline for variability analysis. After normalizing each sector's data by the sector median flux, we evaluated its periodicity and bursting tendencies via the M and Q metrics (Cody et al. 2014). Using all data, we find J0808 is an aperiodic dipper (rather than symmetric, as in Silverberg et al. 2020). The light curve is presented below, with pan/zoom enabled in the interactive poster. We identify two flares in Sector 10, and a third in Sector 31. A low flare rate could contribute to the disk's long life.



Explanations for Gas-Rich Circumstellar Disks At 45 Myr: Long-lived Primordial or "Hybrid" Disks?

We find that the existence of gas-rich (given apparent ongoing accretion) disks around 45-Myr low-mass stars most probably indicates a population of long-lived primordial or "hybrid" disks. While primordial disks around low-mass stars are known to dissipate more slowly than around high-mass stars (e.g. Carpenter et al. 2009), this extends that trend to a much-longer-than-expected planet formation timescale for these stars. It suggests the presence of low-viscosity "dead zones" (Matsamura & Pudritz 2006) in the disk, which could be the formation region for ice giants and terrestrial planets. Long-lived primordial disks could also induce eccentricity damping and convergent migration in a forming planetary system to yield compact systems in resonant chains (Quarles et al. 2017), akin to the TRAPPIST-1 system (Gillon et al. 2016, 2017). This predicts "Peter Pan" disks are relatively common. Extrapolating from the disk fraction for M stars in young groups (e.g. Upper Scorpius; Esplin et al. 2018), Peter Pan disks should then occur at a rate that leads to a **disk fraction of ~1% in 45-Myr YSAs.** The identification of a Peter Pan disk in the 50-Myr Argus association (Lee et al. 2020) suggests that the phenomenon extends to older ages as well. Modeling work based on the observed Peter Pan disk characteristics indicate that low transport, low external photoevaporation, and high initial disk masses are necessary conditions (Coleman & Haworth 2020), suggesting an origin on the outskirts of star-forming regions.



Testing Our Hypothesis with Citizen Science: Disk Detective v2.0

Testing our hypothesis that Peter Pan disks are common requires finding more examples. To that end, we have developed Disk Detective version 2.0, a relaunched version of the original Disk Detective project (Kuchner et al. 2016) that first identified J0808 (Silverberg et al. 2016). This version incorporates data from *Gaia* EDR3, Pan-STARRS PS1, Skymapper, and unWISE co-adds, to provide improved resolution and focus on nearby systems. Good disk candidates are evaluated for YSA membership via BANYAN Σ (Gagne et al. 2018), to identify new disk-hosting YSA members and thus new Peter Pan disk candidates for follow-up observations. To learn more about Disk Detective v2.0, including ongoing and recently-published work, we encourage you to visit our blog, or **try the website for yourself by clicking the thumbnail.**

References

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