The Eroding Disk of the Young M Star AU Mic

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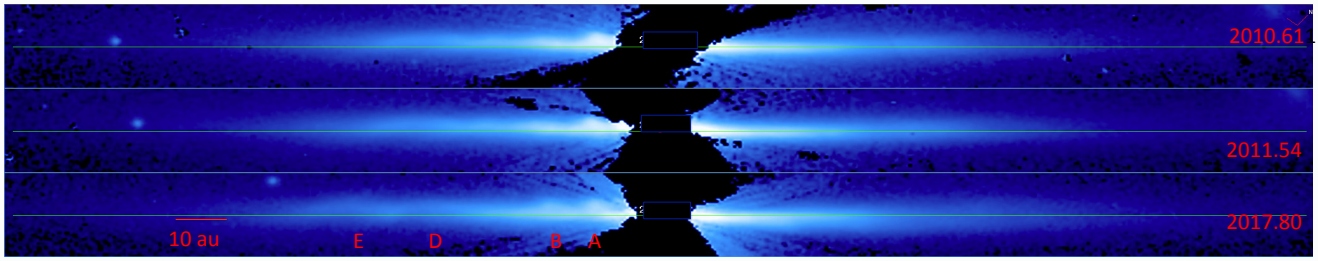
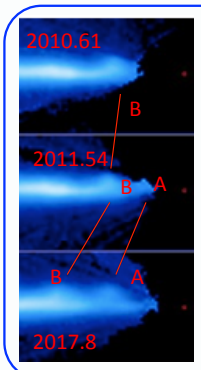


Abstract: AU Mic (M1V, d=9.79 pc GAIA consortium 2016; t=24±3 Myr Bell et al. 2014) hosts a nearby debris disk. A distinctive feature is the presence of a series of arc-like structures on one side of the star. Comparison of SPHERE data from 2014 with HST data from 2010/2011 revealed the features were moving outward at between 4 -10 km/s (Boccaletti et al. 2015), and that 3 were moving at greater than escape velocity. The outward motion continues. HST observations resumed in 2017 October and confirm the disk is now more diffuse, and the features are now well-resolved. For the first time we find a velocity component orthogonal to the outer disk in addition to the motion along the disk. These findings are compared with available models.

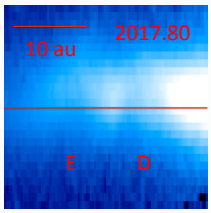


Features continue to move outward, with largest velocity component along disk midplane.

We now see a smaller velocity component perpendicular to the disk.

Feature B in particular has broadened over time, which may account for difficulties in measuring its centroid from ground-based data, and now shows a larger separation from feature A.

Shapes of Features Changed Over Time: Features A & B show signs of central clearing in 2017, but D & E now are well-resolved partial arcs, with centrally cleared regions, and little material in or below the disk midplane.



The projected size of features D & E is comparable to the size of coronal mass ejections in our outer Solar System.

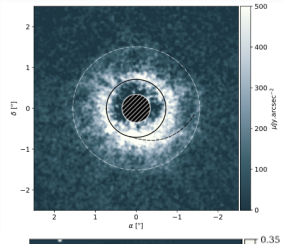
Disk Rotation: The absence of material in the midplane for features D & E suggests that they are largely centrally cleared, and if viewed face-on, may resemble structures imaged in the outer disk of TWA 7. This process appears less advanced in A & B where material in the midplane is seen for both features, and clearing is only marginally detected. Over time it may be possible to trace disk rotation from the projected shapes of these features.

No inner disk: We subtracted a simplified model disk from The STIS imagery, **but did not recover an inner disk**. The AU Mic system differs from β Pic in this regard.

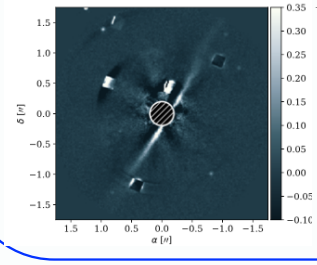
Sezestre et al. (2017) modeled the features as dust structures ejected from an unspecified parent body, modeled either as an stationary body at 27±8 au or an orbiting body at 8±2 au. They considered bodies orbiting in the disk midplane, but our detection of an out-of-plane velocity component suggests that any orbiting parent body orbits out of the disk midplane. Alternatively, the size of the features suggests a link to massive coronal mass ejections associated with higher energy flaring in this active star.

Remaining Disk Lifetime: Assuming a planetesimal belt mass of 0.17 earth masses (Daley et al. 2018), features of 4×10^{-7} earth masses (Chiang & Fung 2017), with 3 lost per decade (Boccaletti et al. 2015), we estimate that the remaining disk lifetime is ~1.4 Myr. If AU Mic is typical, this implies that M star debris disks are limited to the first ~30 Myr of a system's life, consistent with Binks & Jeffries (2017). With this limit, M star debris belts last long enough to produce terrestrial planets, but not long enough to be a source for water and organics for them, as has been suggested for the young Earth.

AU Mic is not unique: Possible analogs



The low inclination system TWA 7 (M3.2, d=34.5 pc) at 8-10 Myr is younger than AU Mic. Sphere imagery at H in polarized light (Olofsson et al. 2018) shows arcs or bubbles in the outer disk, which may be similar to features D & E in AU Mic.



Sissa et al. (2018) reported the presence of "ripples" in the disk of GSC 07396-00759 (M1 IVe, member of βPMG). These structures may be analogs of the features in AU Mic as seen at 73 pc.

This work is based on data obtained with the Hubble Space Telescope under HST-GO-12228 and HST-GO-15219.