A Transiting Extrasolar Ring System: Indirect Evidence for Exosatellite Formation?

Credit: Ron Miller

Matthew Kenworthy // Leiden Observatory EPSC // 30 September 2015

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Young pre-MS stars in an OB Association



Pre-MS Candidate J1407





d = 133 +- 12 pc (kinematic distance)

Photometry consistent with 16 Myr isochrones



Baraffe et al. (1998) isochrones

The star follows BB curve



Super Wide Angle Survey for Planets (SWASP)



Rapid photometry (30 sec) using several wide angle cameras

Searching for hot Jupiter transits

SuperWASP South (SALT, South Africa)

Pollacco et al. 2006, Butters et al. 2010

All Sky Automated Survey (ASAS)



Maps whole sky about once every three days

Long term photometric monitoring for variables

SuperWASP South (LCO, Chile)

Pre-MS Candidate J1407



12.7 mag, K5 pre-MS star



Central eclipse duration of 56 days



van Werkhoven et al. (2014)



Eclipse by substellar companion alone?



NO - can't get 95% eclipse

Red giant eclipsing a bluer hotter star?



NO - system too young for NS or WD NO - no strong X-ray source

Circumbinary/stellar disk?



NO - Not enough NIR excess

NO - Cannot reproduce eclipse structure

Eclipse by a large ring system



Estimating the size of the object

$33 \text{ km.s}^{-1} \times 56 \text{ days} \sim 0.8 \text{AU}$

How the rings change the light curve of J1407



Rings smoothed by star's disk gives the ring plane geometry





Min. speed [km/s]

Rings smoothed by star's disk gives the ring plane geometry



Saturn's rings



radius

Tiscareno review 2013 and Colwell 2009

Mass of J1407b's rings equals 0.6 Earth



...and are we seeing clearing out with an exomoon?



Ring system 200 times bigger than Saturn's rings



...and ultimately unstable - will accrete into moons

If you put the rings around Saturn....

...we'd be able to see it at twilight from Earth!

Is this possible?



Hill radius

RO

Hill sphere filling fraction is ξ

Radial Velocity



Keck and VLT imaging



Dynamical Stability



Ruling out other transits









Conclusions



J1407b is easily reachable from the ScoCen Terminus. Di-weekly jumps to Mamajek Orbital Station, and then daily gliders to Port Anja.



- Rings fill the Hill sphere
- Photometric followup
- Looking for the rings using ALMA and ZIMPOL
- The hunt for rings in archival data (Leiden master's student Julia Heuritsch)

Papers, data and code at: http://bit.ly/j1407b



Geometry of Eclipsing ring





Eclipsing by a ring system



Time