Spitzer Eclipse Observations of Exoplanet WASP-34b

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Abstract

WASP-34b is a short-period exoplanet with a mass of 0.59 ± 0.01 Jupiter masses orbiting a G5 star with a period of 4.3177 days and an eccentricity of 0.038 ± 0.012 (Smalley, 2011). We observed WASP-34b using the 3.6 and 4.5 μm channels of the Infrared Array Camera (IRAC) aboard Spitzer in 2010 (Program 60003). Our Photometry for Orbits, Eclipses, and Transits (POET) pipeline does not find a significant (3σ or greater) eclipse depth detection at 3.6 μm, so we report a 99.5% upper limit on eclipse depth of 0.0562%. At 4.5 μm we find an eclipse depth of 0.0637 ± 0.0188%. We discuss low temperature, orbital geometry, and atmospheric composition as possible causes for the non-detection at 3.6 μm.

POET

POET is a modular process that corrects for bad pixels and *Spitzer* systematics, determines the center of the target, does interpolated aperture photometry, and then uses Markov-chain Monte Carlo to fit light-curve models to the data to determine free parameters like eclipse phase, depth, and duration. POET allows us to compare various light-curve models to determine the best centering method, aperture size, and systematic corrections.

Channel 1

Our observation of WASP-34b with the 3.6 μm channel does not contain a significant eclipse. To aid with MCMC convergence, we applied Gaussian priors of 0.017 ± 0.002 orbits and 0.5185 ± 0.0076 to eclipse duration and midpoint, respectively, based on Smalley et al. (2011). We also applied a Gaussian prior to the ingress/egress time of half the predicted duration, due to the probable grazing nature of the eclipse. We find a 99.5% upper limit of 0.0562% on eclipse depth.

Normalized Binned WASP-34b Data With Eclipse Models
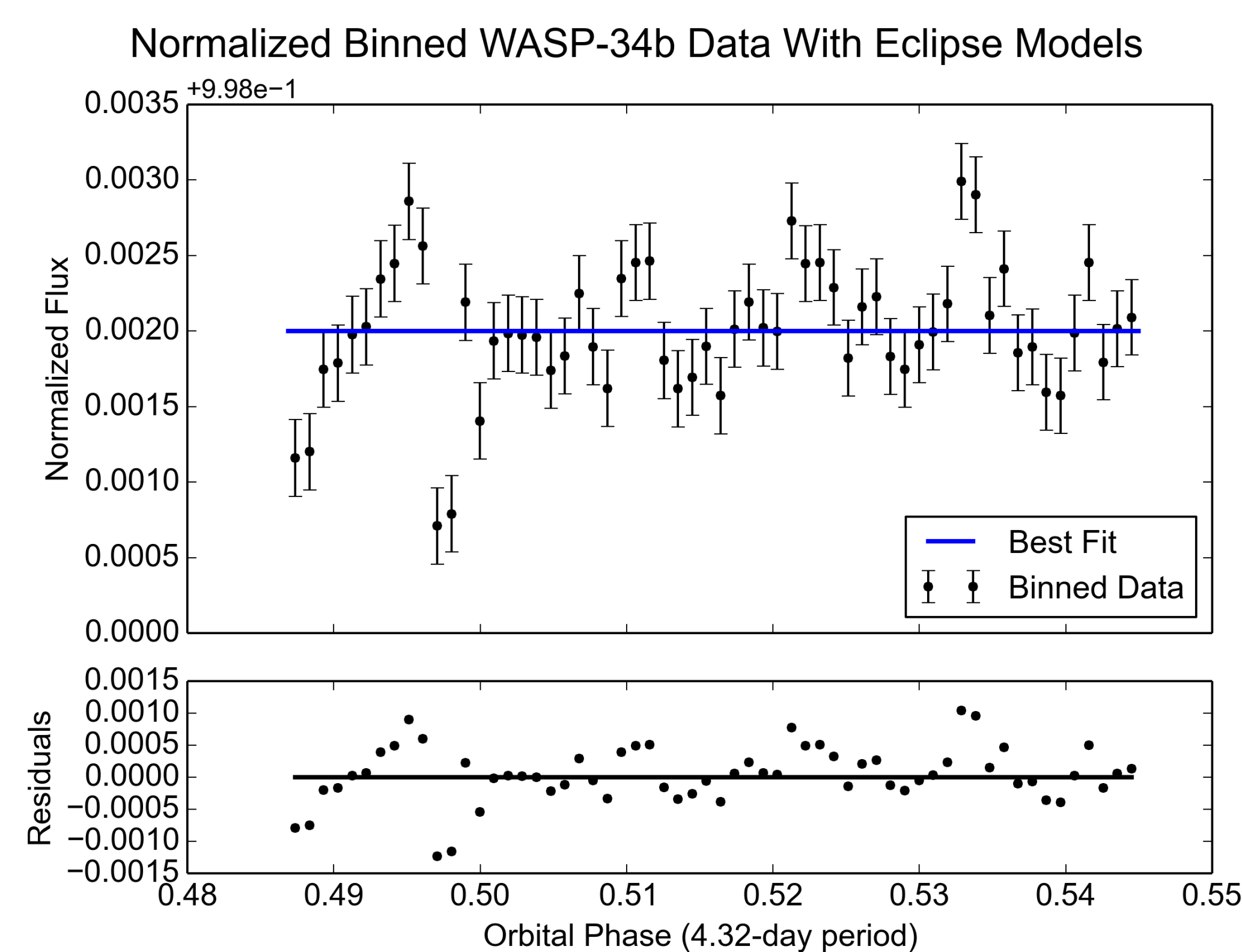
Channel 2

In the 4.5 μm channel we find a weak eclipse with a depth of 0.0637 ± 0.0188%. Again, we applied Gaussian priors to eclipse duration and midpoint based on Smalley et al. (2011), and to the ingress/egress time, in the same manner as was done with channel 1. This eclipse depth corresponds to a brightness temperature of 1102 ± 118 K.

Normalized Binned WASP-34b Data With Eclipse Models
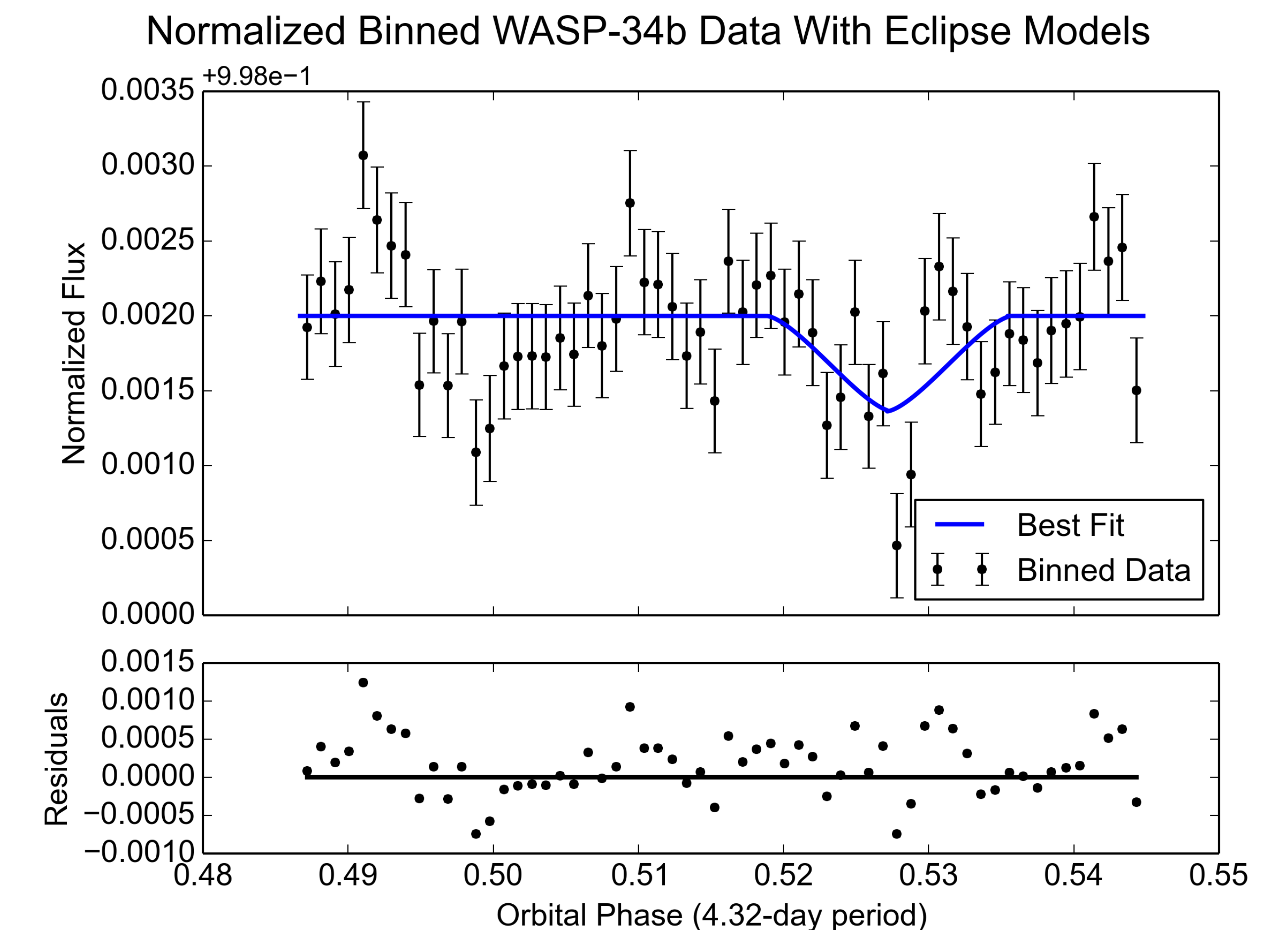
Discussion

There are several possible contributing factors to the low S/N detections:

1. We calculated the equilibrium temperature to be 1158 K, assuming zero albedo and perfect heat distribution. This is relatively low, and these assumptions are unrealistic, so the planet may be even cooler.

2. WASP-34b is known to undergo grazing transits, making it possible that the eclipses are also grazing. This could significantly reduce the signal, although without precise orbital parameters it is difficult to quantify how much.

3. It is possible to detect an exoplanet eclipse in one channel and not in the other (Stevenson et al., 2012). The atmosphere of WASP-34b could contain molecules with features in the 3.6 μm channel, such as methane, that reduce eclipse depth.

Acknowledgements

References

Smalley et al 2011A&A...526A.130S
Campo et al 2011ApJ...727..125C
Stevenson et al 2012ApJ...755....9S
Cubillos et al 2012DPS....4410308C

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