Close-in planets around evolved stars: the peculiar case of Kepler-432b

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ABSTRACT

The number of Jupiter-like planets found to orbit evolved stars has constantly grown in recent years. These discoveries have found an **apparent lack of close-in (a < 0.5 AU) giant planets orbiting giant/subgiant stars**. If this scarcity of planets around evolved stars is not an observational effect, it could have important implications for planet formation/evolution models. We present the discovery of Kepler-432b, a rare case of a **warm-Jupiter planet transiting a giant star**. This planet is among the most massive and dense transiting planets known so far and it is orbiting at only 0.3 AU from its host star with a period of ~52 days. Kepler 432b occupies an almost **desert region in the parameter space** for planets around giant stars, which makes it a unique object for studying the evolution of planetary systems after the host star leaves the main-sequence. Current post-main-sequence evolution models predict that Kepler 432b **will be swallowed by its host star in less than 200 million years**.

INTRODUCTION

More than **60 exoplanets** have been found around giant stars so far. These discoveries have demonstrated that the gas-giant planet population around evolved stars possesses **different orbital properties** than the population of planets orbiting main-sequence (MS) stars. The main characteristics of planets around giant stars can be summarized as follows:

- They are **more massive** than planets around MS stars with masses between 3-10 $M_{Jup.}$
- In average, they show **low values** for the eccentricity.
- In general, they have periods **larger than** ~ 100 days.
- There is an **apparent lack of close-in planets** with semi-major axes of less than 0.5 AU.

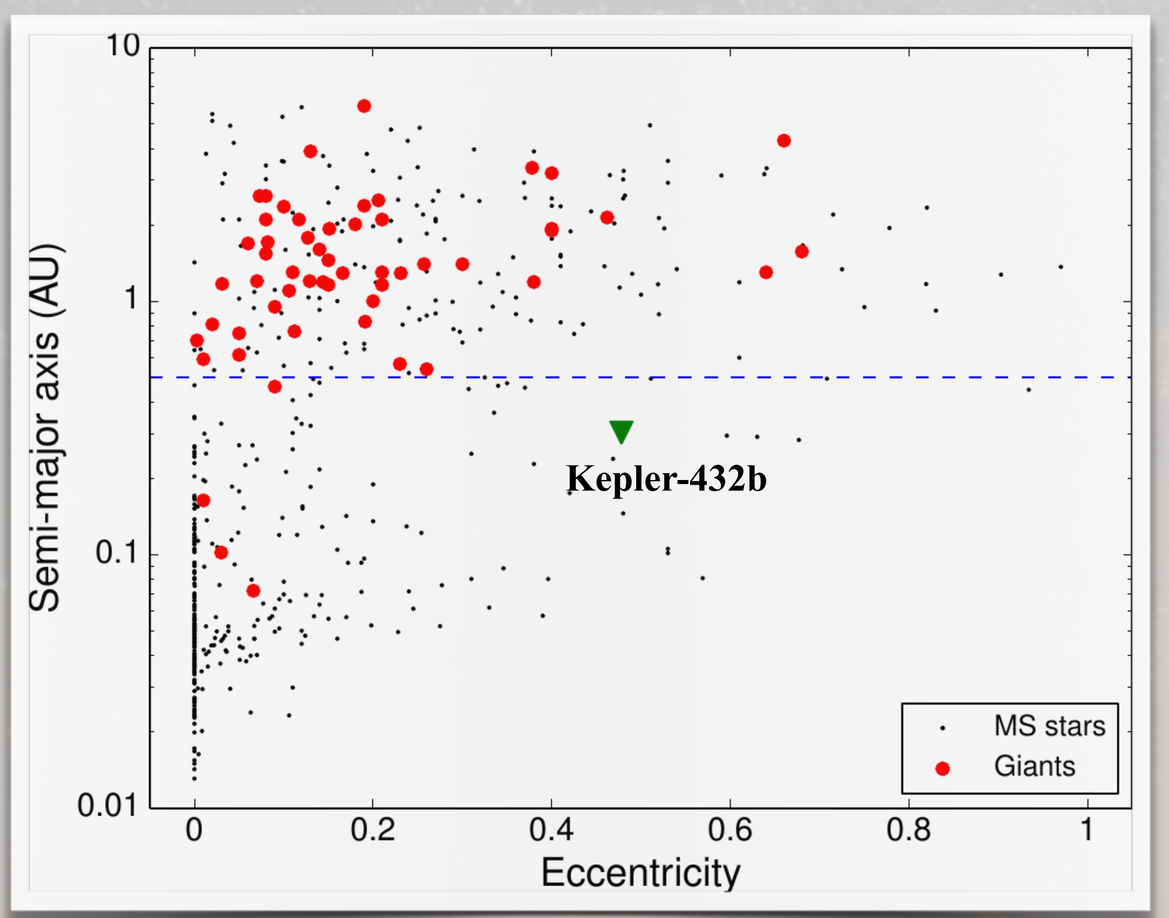

Figure 1. Eccentricity and semi-major axis of the extrasolar planets discovered around MS stars (black dots) and giant stars (red circles). The dashed line shows the value of a = 0.5 AU.

Two different mechanisms have been proposed to explain the **paucity of close-in planets** around giant stars. The first one states that, as a result of stellar evolution, the inner planets are **tidally engulfed by their host stars** as the outer planets move farther out. The second one suggests that although giant planets may form around intermediate-mass stars, they **do not migrate inwards**, owing to the short dissipation time-scale of protoplanetary disks.

RESULTS

We have obtained radial velocity observations of the giant star Kepler-432 (**Fig. 2**) to confirm the planetary nature of a transiting object first observed by the *Kepler* telescope. The planet, **Kepler-432b**, is a warm gas-giant planet orbiting at only **0.303 ± 0.007 AU** from its host star.

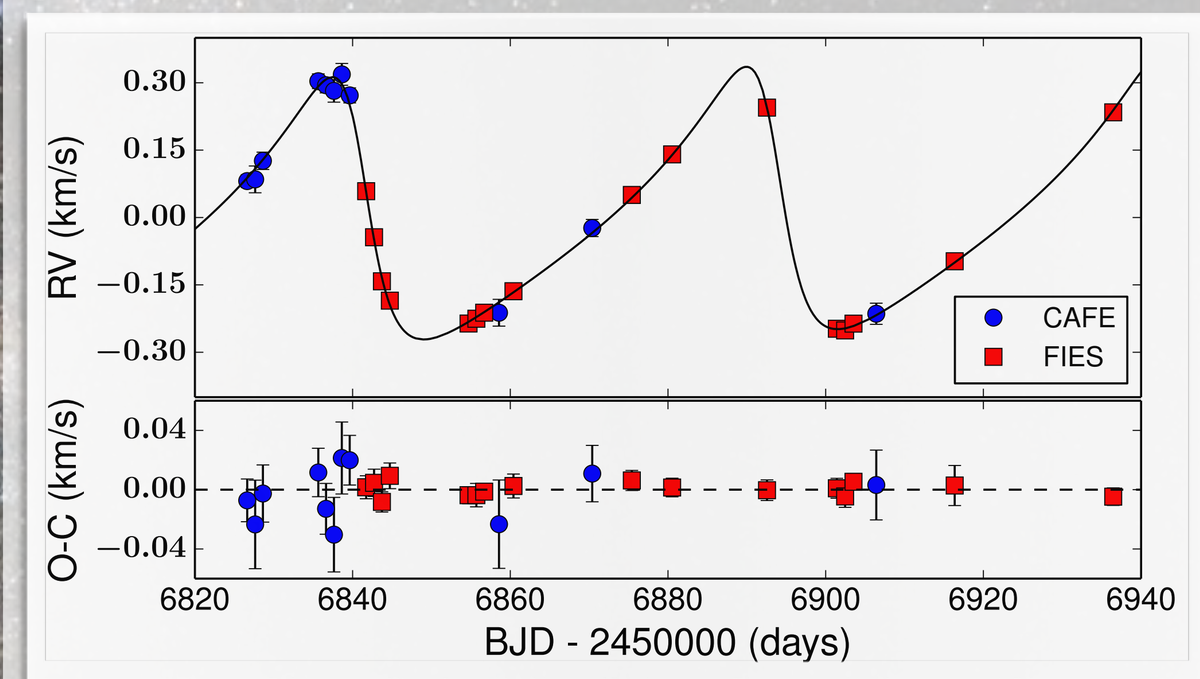

Figure 2. Radial velocity measurements of Kepler-432 taken with the CAFE (blue circles) and FIES (red squares) spectrographs, and the best Keplerian fit to the data (black solid line). Also shown are the residuals from the fit.

Kepler-432b has a mass of **5.84 ± 0.05 M_{Jup}** and a high density of **5.4 ± 0.5 g cm^{-3}**. Among planets orbiting giant stars, Kepler-432b is very peculiar both in terms of the eccentricity and orbital period, as it occupies a scarcely populated region in this parameter space (**Fig. 1**). Gravitational migration might be able to explain both the large eccentricity of **0.478 ± 0.004** and the small semi-major axis of the orbit.

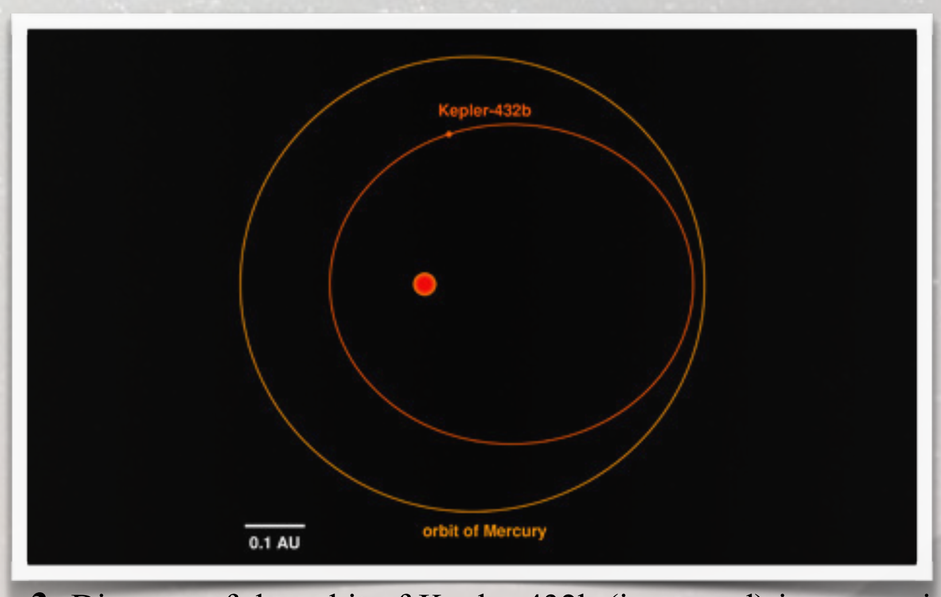

Figure 3. Diagram of the orbit of Kepler-432b (inner, red) in comparison to the orbit of Mercury around the Sun (outer, orange). The orbit of Kepler-432b is highly elongated. As a consequence, the distance between the planet and the star as well as the temperature on the planet change dramatically during a single orbit.

CONCLUSIONS

- Kepler-432b is among the **more massive and dense** transiting exoplanets discovered so far.
- Outlier for planets around giant stars: **very eccentric and close-in planet**.
- The lack of close-in planets around giant stars can be ascribed to **enhanced tidal dissipation** and subsequent **stellar engulfment** during the RGB phase.
- Models of post main-sequence evolution predict that **Kepler-432b will be swallowed** by its host star in less than 200 million years.

AFFILIATIONS

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REFERENCES

Reference of the full paper:
Ortiz, M., Gandolfi, D., Reffert, S., et al. 2015, A&A, 573, L6
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