Kepler-47 Circumbinary Planets obey Quantization of Angular Momentum per Unit Mass predicted by Quantum Celestial Mechanics (QCM)

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The Kepler-47 circumbinary system has three known planets orbiting its binary star barycenter and therefore can provide a precision test of the Quantum Celestial Mechanics (QCM) prediction of the quantization of angular momentum per unit mass in all gravitationally bound systems. Two of the planets are in the Habitable Zone (HZ), so system stability can be a primary concern. QCM may be a major contributor to the stability of this system.

1 Introduction

We report another precision test of quantum celestial mechanics (QCM) in the Kepler-47 circumbinary system that has three planets orbiting its two central stars. QCM, proposed in 2003 by H.G. Preston and F. Potter [1] as an extension of Einstein's general theory of relativity, predicts angular momentum per unit mass quantization states for bodies orbiting a central mass in all gravitationally bound systems with the defining equation in the Schwarzschild metric being

$$\frac{L}{\mu} = m\,\frac{L_T}{M_T}\,. \tag{1}$$

Here μ is the mass of the orbiting body with orbital angular momentum L and M_T is the total mass of the bound system with total angular momentum L_T. We determine that the quantization integers m are 4, 6, and 7, for the three circumbinary planets 47-b, -d, -c, respectively, with a linear regression fit $R^2 = 0.9993$. Note that in all systems we have considered, we assume that the orbiting bodies have been in stable orbits for at least a 100 million years.

In other two-star systems with one or two circumbinary planets, the two stars contributed more than 95% of the total angular momentum of the system. In Kepler-47, the three known planets are contributing at least 25% of the angular momentum, a significant fraction, so Kepler-47 provides an additional test of QCM.

As we determined in the paper cited above, in the Solar System the Oort Cloud dominates the total angular momentum, its contribution being nearly 60 times the angular momentum of the planets, but the value has large uncertainty. In the numerous multi-planetary systems around a single star for which we have checked the QCM angular momentum quantization restriction [2], not only do the planetary orbits contribute much more angular momentum than the star rotation, but also each was determined to require additional angular momentum contributions from more planets and/or the equivalent of an Oort Cloud.

We find also that Kepler-47 could have more angular momentum contributions beyond the angular momentum sum of the binary stars and the three planets.

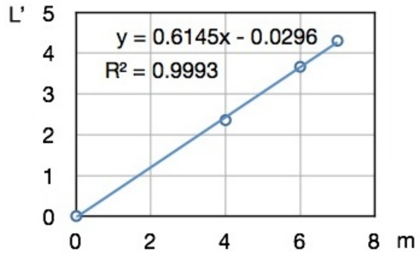

Fig. 1: Kepler-47 System m values predicted by QCM.

2 Results

W.F. Welsh, J.A. Orosz, et al. [3,4] have recently reported the properties of the Kepler-47 system:

- Stars A and B have masses 1.04 ± 0.06 $M_\odot$ and 0.36 $M_\odot$ with orbital period 7.45 days.
- Planet 47-b has mass < $2M_{Jup}$, orbital period 49.53 days and orbital eccentricity $e < 0.035$.
- Planet 47-c has mass < $28M_{Jup}$, orbital period 303.1 days and orbital eccentricity $e < 0.2$.
- Planet 47-d has orbital period 187.3 days, unknown eccentricity, and unknown mass value.

Planet-c is definitely within the Habitable Zone (HZ) and so is planet 47-d. As the authors state, Kepler-47 establishes that planetary systems can form and persist in the chaotic environment close to binary stars as well as have planets in the HZ around their host stars.

In order to use the angular momentum condition, one assumes that the orbiting body is at or near its QCM equilibrium orbital radius r and that the orbital eccentricity ϵ is low so that our nearly circular orbit approximation leading to the quantization equation holds true. Therefore, the L of the orbiting body will agree with its Newtonian value $L = \mu\sqrt{GM_T r(1-\epsilon^2)}$.

In Fig. 1 is shown a plot of $L' = L/\mu$ versus m for the three known planets in the Kepler-47 system. The circles about the data points contain the uncertainty bars for L'. The slope b of the line in this plot is used to predict the system's total angular momentum $L_T = bM_T$ multiplied by 10^{15} kg-m^2/s.

The QCM predicted value of 17.7×10^{44} kg-m^2/s is much larger than the estimated upper value of 12×10^{44} kg-m^2/s from the five bodies in orbit about the barycenter. Therefore, QCM predicts additional sources of angular momentum for this Kepler-47 system.

What are possible additional sources for the QCM predicted total angular momentum? There could be massive bodies at $m = 3, 5, 8, 9, \ldots$ However, massive bodies with sufficient orbital angular momentum at either $m = 3$ or $m = 5$ would have been detected already by their perturbation effects on the known planets, so the additional planetary angular momentum must be exterior to planet 47-c, i.e., will have $m > 7$. Perhaps new sources will be detected in the near future to provide another check on the QCM quantization condition.

3 Conclusions

The Kepler-47 system provides further evidence that angular momentum has a primary role in gravitationally bound systems at all scale sizes, particularly in determining the spacings of planetary orbits in solar systems, of satellites of planets [5], of planets in circumbinary systems, as well as determining physical properties of galaxies, clusters of galaxies, and the Universe.

Although the three known planets in Kepler-47 have an excellent fit to the QCM quantization condition, further orbiting bodies are predicted that could provide an additional test when they are detected. If they are located at orbital radii that do not agree with acceptable values, QCM will be challenged to explain the discrepancies.

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