Kepler-16 Circumbinary System Validates Quantum Celestial Mechanics

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We report the application of quantum celestial mechanics (QCM) to the Kepler-16 circumbinary system which has a single planet orbiting binary stars with the important system parameters known to within one percent. Other gravitationally bound systems such as the Solar System of planets and the Jovian satellite systems have large uncertainties in their total angular momentum. Therefore, Kepler-16 allows us for the first time to determine whether the QCM predicted angular momentum *per mass* quantization is valid.

1 Introduction

We report a precision test of quantum celestial mechanics (QCM) in the Kepler-16 circumbinary system that has planet-b orbiting its two central stars at a distance of 0.70 AU from the barycenter. 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 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 calculate that the quantization integer $m = 10$, an amazing result with about a 1% uncertainty. Note that in all systems tested, we assume that the orbiting bodies have been in stable orbits for at least a 100 million years.

Kepler-16 is the first solar system type for which the total mass and the total angular momentum are *both* known accurately enough to allow a test of the angular momentum per mass quantization condition to within a few percent. The advantage this system has over all others is that the binary stars in revolution at its center contribute more than 99.5% of the system's total angular momentum. Moreover, more orbiting bodies may be detected in the future to provide the acid test of the theory because our precision result should improve.

2 Brief Review

Contrary to popular statements in the literature about planetary orbital angular momentum, the angular momentum of the Oort Cloud dominates the total angular momentum of the Solar System, being about 60 times the angular momentum of the orbiting planets, but its value has high uncertainty. The Jovian planets have differential internal rotations which bring their angular momentum uncertainties to more than 10% also. The Earth-Moon and Pluto-Charon systems have known values and a fit can be made to $m = 65$ and $m = 9$, respectively, but the application of the Schwarzschild metric is questionable in systems for which a reduced mass must be used. In addition, there is not another orbiting body for prediction purposes.

The Mars-Phobos-Deimos system offers a test of the angular momentum condition. We find that $m = 61$ for Phobos and $m = 97$ for Deimos, with uncertainties less than about 4%. The Schwarzschild metric is a good approximation here but the integers are very large and therefore somewhat unsatisfactory for a definitive test. We would prefer to find a system for which the m values that fit are small integers, if possible.

We have applied the equation to many multiplanet exosystems and found that the fits all predict additional undetected angular momentum. Such solar systems can be expected to have an additional planet and/or the equivalent of an Oort Cloud that contributes significant orbital angular momentum. Examples include: Kepler-18, HR 8799, HIP 57274, Gliese 581, 55Cnc, Kepler-11, PSR 1257, HD 10180, HD 125612, HD 69830, 47 Uma, and 61 Vir.

Other confirmed circumbinary systems with one or two known planets are either dominated by the planetary angular momentum or the planets contribute about 50%, rendering their fits unsuitable for a precision test: HW Virginis, NNSerpentis, and DP Leonis.

Our original article [1] contains the derivation of QCM from the general relativistic Hamilton-Jacobi equation and its new gravitational wave equation for any metric. Our first application, to the Solar System without knowledge of the Oort Cloud angular momentum, predicted that all the planetary orbits should be within the Sun's radius! Subsequently, we learned about the Oort Cloud and were able to produce two excellent QCM linear regression fits with $R^2 > 0.999$ for m sets (1) 2,3,4,5,9,13,19,24,28; (2) 3,4,5,6,11,15,21,26,30. Therefore, we predict a total angular momentum for the Solar System $L_{SS} \approx 1.9 \times 10^{45}$ kg m^2/s with the planets contributing only $L_{pl} = 3.1 \times 10^{43}$ kg m^2/s.

Several follow-up articles verify its application to galaxies without requiring 'dark matter' for gravitational lensing by the galaxy quantization states [2], the quantization state of baryonic mass in clusters of galaxies [3], and how the cosmological redshift is interpreted as a gravitational redshift that agrees with the accelerated expansion of the Universe [4]. That is, QCM applied to the Universe with the interior metric dictates that every observer at distance *r* from the source sees the light originating from an effective negative potential $V(r) \approx -kr^2 c^2/[2(1-kr^2)^2]$, meaning the clocks run slower at the distant source.

In the Schwarzschild metric the QCM wave equation reduces to a Schrödinger-like equation that predicts quantization states for the angular momentum per mass and for the energy per mass. There is no Planck's constant per se but instead each system has its unique constant $H = L_T/M_T c$, a characteristic distance for the gravitationally bound system. Important physical quantities can be related to H and the Schwarzschild radius. In the single free particle limit, such as a free electron, the QCM equation reduces to the standard quantum mechanical Schrödinger equation. Note that QCM is not quantum gravity.

3 The Kepler-16 System

We have been waiting about 10 years for a gravitationally bound system for which its total angular momentum per total mass is known to about 1%. Finally, in September, 2011, the Kepler-16 system was reported [5] with two stars, star A and star B, separated by 0.22 AU and a planet called planet-b orbiting their barycenter at 0.70 AU. The list below provides the important physical parameters of this system.

Star A:

Mass = 0.6897 ± 0.0035 solar masses

Orbital radius = 0.05092 ± 0.00027 AU

Period = 41.079220 ± 0.000078 days

Angular momentum = $(1.4247 \pm 0.0170) \times 10^{44}$ m^2/s

Star B:

Mass = 0.20255 ± 0.00066 solar masses

Orbital radius = 0.17339 ± 0.00115 AU

Period = 41.079220 ± 0.000078 days

Angular momentum = $(4.8514 \pm 0.0632) \times 10^{44}$ m^2/s

planet-b:

Mass = 0.333 ± 0.0016 Jupiter masses

Orbital radius = 0.7048 ± 0.0011 AU

Period = 228.776 ± 0.037 days

Angular momentum = $(2.2479 \pm 0.1080) \times 10^{42}$ m^2/s

Kepler-16 system:

$L_T/M_T = (3.517 \pm 0.011) \times 10^{14}$ m^2/s

$L_b/M_b = (3.555 \pm 0.036) \times 10^{15}$ m^2/s

Note that although the planet mass value has about a 5% uncertainty, this large uncertainty is excluded from the equation because the planet mass divides out in L_b/μ_b. Our result for the QCM angular momentum per mass quantization integer is

$$m = 10.1 \pm 0.1. \qquad (2)$$

Therefore, we have determined that planet-b is in the $m = 10$ quantization state with a maximum uncertainty of less than 2%. In Einstein's general theory of relativity and in Newtonian gravitation there is no a priori reason for *m* to be an integer, so its value could have been anywhere.

4 Comments

As good as this result has been, the acid test for QCM is yet to come. We need to detect at least one more planet in the Kepler-16 system to determine whether the QCM prediction leads to its correct angular momentum value, i.e., an integer multiple of L_T/M_T equal to the classical value at radius *r*.

Assuming that QCM passes the acid test, we wish to point out that the existence of quantization states of angular momentum per mass and energy per mass are important concepts for the formation of stars, planets, solar systems, galaxies, and clusters of galaxies. Models ignoring QCM will be incomplete and will need speculative inventions such as dark matter and perhaps dark energy to preserve traditional incomplete approaches toward 'understanding' these gravitational systems.

An additional gravitational test of QCM would be a laboratory experiment with a slowly rotating attractor mass producing a repulsive effect to counteract the Newtonian attraction at specific rotation frequencies for the given separation distance to the affected mass. We are in the process of searching for this behavior.

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