Pluto Moons exhibit Orbital Angular Momentum Quantization per Mass

Franklin Potter
Sciencegems.com, 8642 Marvale Drive, Huntington Beach, CA, 92646, USA. E-mail: frank11hb@yahoo.com

The Pluto satellite system of the planet plus five moons is shown to obey the quantum celestial mechanics (QCM) angular momentum *per mass* quantization condition predicted for any gravitationally bound system.

The Pluto satellite system has at least five moons, Charon, P5, Nix, P4, and Hydra, and they are nearly in a 1:3:4:5:6 resonance condition! Before the recent detection of P5, Youdin et al. [1] (2012) analyzed the orbital behavior of the other four moons via standard Newtonian gravitation and found regions of orbital stability using distances from the Pluto-Charon barycenter.

I report here that these five moons each exhibit angular momentum quantization *per mass* in amazing agreement with the prediction of the quantum celestial mechanics (QCM) proposed by H. G. Preston and F. Potter [2, 3] in 2003. QCM predicts that bodies orbiting a central massive object in gravitationally bound systems obey the angular momentum L per mass μ quantization condition

$$\frac{\mathrm{L}}{\mu} = mc\mathrm{H}, \tag{1}$$

with m an integer and c the speed of light. For most systems studied, m is an integer less than 20. The Preston gravitational distance H defined by the system total angular momentum divided by its total mass

$$\mathrm{H} = \frac{\mathrm{L_T}}{\mathrm{M_T}c} \tag{2}$$

provides a characteristic QCM distance scale for the system.

At the QCM equilibrium orbital radius, the L of the orbiting body agrees with its Newtonian value $\mu\sqrt{GM_T r}$. One assumes that after tens of millions of years that the orbiting body is at or near its QCM equilibrium orbital radius r and that the orbital eccentricity is low so that our nearly circular orbit approximation leading to these particular equations holds true. For the Pluto system, Hydra has the largest eccentricity of 0.0051 and an m value of 12.

Details about the derivation of QCM from the general relativistic Hamilton-Jacobi equation and its applications to orbiting bodies in the Schwarzschild metric approximation and to the Universe in the the interior metric can be found in our original 2003 paper [2] titled "Exploring Large-scale Gravitational Quantization without $\hbar$ in Planetary Systems, Galaxies, and the Universe". Further applications to gravitational lensing [4], clusters of galaxies [5], the cosmological redshift as a gravitational redshift [6], exoplanetary systems and the Kepler-16 circumbinary system [7] all support this QCM approach.

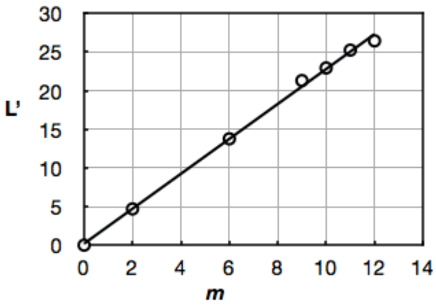

Fig. 1: The Pluto System fit to QCM

Table 1: Pluto system orbital parameters

	$r \times 10^6$ m	period (d)	ϵ	m	P_2/P_1
Pluto	2.035	6.387230	0.0022	2	
Charon	17.536	6.387230	0.0022	6	1
P5	42.	20.2	~ 0	9	2.915
Nix	48.708	24.856	0.0030	10	3.880
P4	59.	32.1	~ 0	11	5.038
Hydra	64.749	38.206	0.0051	12	6.405

The important physical parameters of the Pluto system satellites from NASA, ESA, and M. Showalter (SETI Institute) et al. [8] as listed at Wikipedia are given in the table. The system total mass is essentially the combined mass of Pluto (13.05×10^{21} kg) and Charon (1.52×10^{21} kg). The QCM values of m in the next to last column were determined by the best linear regression fit ($R^2 = 0.998$) to the angular momentum quantization per mass equation and are shown in the figure as $L' = L/\mu c$ plotted against m with slope $H = 2.258$ meters. Using distances from the center of Pluto instead of from the barycenter produces the same m values ($R^2 = 0.995$) but a slightly different slope.

In QCM the orbital resonance condition is given by the period ratio given in the last column calculated from

$$\frac{\mathrm{P_2}}{\mathrm{P_1}} = \frac{(m_2+1)^3}{(m_1+1)^3}. \tag{3}$$

With Charon as the reference, this system of moons has nearly a 1:3:4:5:6 commensuration, with the last moon Hydra having the largest discrepancy of almost 7%. If Hydra moves further out from the barycenter toward its QCM equilibrium orbital radius for $m = 12$ in the next few million years, then its position on the plot will improve but its m value will remain the same. Note also that P5 at $m = 9$ may move slightly closer to the barycenter. Dynamic analysis via the appropriate QCM equations will be reported later. Note that additional moons of Pluto may be found at non-occupied m values.

The QCM plot reveals that not all possible m values are occupied by moons of Pluto and at the same time predicts orbital radii where additional moons are expected to be. The present system configuration depends upon its history of formation and its subsequent evolution, both processes being dependent upon the dictates of QCM. Recall [2] that the satellite systems of the Jovian planets were shown to obey QCM, with some QCM orbital states occupied by more than one moon.

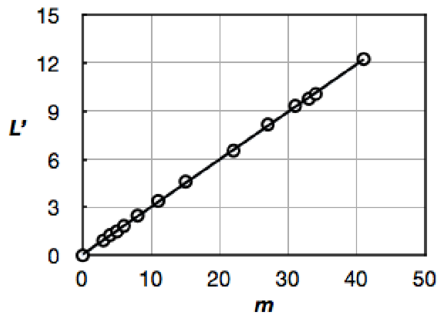

Fig. 2: The Solar System fit to QCM

I show in Fig. 2 the linear regression plot ($r^2 = 0.999$) for the Solar System, this time with 8 planets plus the largest 5 additional minor planets Ceres, Pluto, Haumea, Makemake, and Eris. From the fit, the slope gives us a Solar System total angular momentum of about 1.78×10^{45} kg m^2/s, far exceeding the angular momentum contributions of the planets by a factor of at least 50! Less than a hundred Earth masses at the 50,000–100,000 A.U. distance of the Oort Cloud therefore determines the angular momentum of the Solar System. Similar analyses have been done for numerous exoplanet systems [7] with multiple planets with the result that additional angular momentum is required, meaning that more planets and/or the equivalent of an Oort Cloud are to be expected.

The existence of angular momentum per mass quantization dictates also that the energy per mass quantization for a QCM state obeys

$$\frac{\mathrm{E}}{\mu} = -\frac{r_g^2 c^2}{8n^2 H^2} = -\frac{G^2 M_T^4}{2n^2 {L_T}^2} \tag{4}$$

with $n = m + 1$ for circular orbits and Schwarzschild radius r_g. One expects $H \gg r_g$ for the Schwarzschild approximation to be acceptable, a condition upheld by the Pluto system, the Solar System, and all exoplanet systems. The corresponding QCM state wave functions are confluent hypergeometric functions that reduce to hydrogen-like wave functions for circular orbits. Therefore, a QCM energy state exists for each $n \geqslant 2$. A body in a QCM state but not yet at the equilibrium radius for its m value will slowly drift toward this radius over significant time periods because the QCM accelerations are small.

In retrospect, the Pluto system is probably more like a binary system than a system with a single central mass, with the moons beyond Charon in circumbinary orbits around the barycenter. As such, I was surprised to find such a good fit to the QCM angular momentum restriction which was derived for the single dominant mass system. Additional moons of Pluto, should they exist, can provide some more insight into the application of QCM to this gravitationally bound system.

Meanwhile, the identification of additional exoplanets in nearby systems, particularly circumbinary planets, promises to create an interesting challenge for establishing QCM as a viable approach toward a better understanding of gravitation theory at all size scales.

Acknowledgements

The author acknowledges Sciencegems.com for its generous support.

Submitted on August 02, 2012 / Accepted on August 07, 2012

References

1. Youdin A. N., Kratter K. M., Kenyon S. J. Circumbinary Chaos: Using Pluto's Newest Moon to Constrain the Masses of Nix & Hydra. arXiv: 1205.5273v1.
2. Preston H. P., Potter F. Exploring Large-scale Gravitational Quantization without h-bar in Planetary Systems, Galaxies, and the Universe. arXiv: gr-qc/030311v1.
3. Potter F., Preston H. G. Quantum Celestial Mechanics: large-scale gravitational quantization states in galaxies and the Universe. *1st Crisis in Cosmology Conference: CCC-I*, Lerner E. J. and Almeida J. B., eds., AIP CP822, 2006, 239–252.
4. Potter F., Preston H. G. Gravitational Lensing by Galaxy Quantization States. arXiv: gr-qc/0405025v1.
5. Potter F., Preston H. G. Quantization State of Baryonic Mass in Clusters of Galaxies. *Progress in Physics*, 2007, v. 1, 61–63.
6. Potter F., Preston H. G. Cosmological Redshift Interpreted as Gravitational Redshift. *Progress in Physics*, 2007, v. 2, 31–33.
7. Potter F., Preston H. G. Kepler–16 Circumbinary System Validates Quantum Celestial Mechanics. *Progress in Physics*, 2012, v. 1, 52–53.
8. Showalter M., Weaver H. A., Stern S. A., Steffi A. J., Buie M. W. Hubble Discovers New Pluto Moon, 11 July 2012. `www.spacetelescope.org/news/heic1212`