Dwarf Planet Resonance in the Kuiper Belt

This update of the "Even More Plutos" chapter of *More Plutos* is also
a heads-up that your software's Dwarf Planet positions might be outdated

By Sue Kientz

Since 2015 when More Plutos *was published, I have noticed periodic corrections being made to the orbital lengths of the Dwarf Planets as published in Wikipedia when updated data are collected. Happily, the updated figures only strengthen my postulation that these planets' meanings reflect their resonance to particular gas giants. In this excerpt from* More Plutos*, orbit lengths and related resonance details are updated. More importantly, Astrodienst and Solar Fire apparently updated their Dwarf Planet longfiles, the ones Solar Fire users have in their computer's SwissEph folder tree. Astrodienst has these updates built-in to their website, but if you have Solar Fire and run a less than current version, you might need to update those SwissEph files for Ixion, Makemake, Haumea, Orcus, and Varuna. The difference is more noticeable the farther you go back in time, although I'm happy to report the difference if only about a degree or so by the time of Augustus Caesar. Expect slight changes to occur in future as well.*

To understand resonance, you need to appreciate that everything in our solar system exerts a gravitational influence on other bodies. If an object is very small, that gravitational influence will be small. But the large bodies like the Sun and the four gas giants exert quite a lot of influence. The Sun ties everything together and has the strongest gravitational field, but for our purposes, we will be paying attention to how Jupiter, Saturn, Uranus, and Neptune are gravitationally influencing the Kuiper Belt bodies.

Previously we mentioned that Pluto's and Neptune's orbits have 2:3 resonance, and how that means that each time Neptune orbits the sun three times, Pluto orbits the sun twice. When you see those small numbers in a resonance, that's not mere coincidence – that's influence. Neptune is much more massive, and each time it moves past Pluto, Pluto "feels" it gravitationally, like a child being pushed on a swing. Pluto is the child, and Neptune is the parent who pushes every time Pluto comes back around. At some point, Pluto had to be in just the right spot to get into this 2:3 swing with Neptune. In other words, Pluto is a survivor. There were almost certainly other objects out there, maybe bigger and certainly smaller than Pluto, that were not in the right place, which Neptune probably "pushed" clear out of the Kuiper Belt, either ejecting them totally out of our system, or sending them into the inner solar system to collide with a planet like Jupiter or break up in some other fashion.

But it's not just Neptune exerting this influence. All the planets over millions of years have been pushing one another and jostling others (or being jostled) into more stable positions. In a way, all the different celestial bodies are in touch with one another like the large and small cogs found inside a watch. Each object's gravity is the invisible system of cogs that has them all connected to one another.

Pluto Has More Pals

By the way, Pluto isn't alone in the patch of Kuiper Belt territory that is close to 2:3 resonance with Neptune. There are other rather large bodies there, too, but they are able to share that same orbital distance and not perturb Pluto, either by not approaching or passing (e.g., conjuncting) Pluto, or by being big, but not too big to disturb Pluto. These two cronies of our disenfranchised member of Sol's Planet Club are the following (Pluto included to compare size and orbital period):

Name	Diameter	Orbits Sun	Resonance	How Closely Resonant?*	Difference
Orcus	917 ±25 km[1]	245.19 yrs	3:25 with ♄	735.57/736.427	0.857
			1:21 with ♃	245.19/249.09	3.9[2]
			2:3 with ♆	490.38/494.37	3.99
			1:3 with ♅	245.19/252.969	7.779
Pluto	**2376.6 km[3]**	**247.94 yrs**	**1:21 with ♃**	**247.94/249.09**	**1.15**
			2:3 with ♆	**495.88/494.37**	**1.51**
			2:17 with ♄	**495.88/500.771**	**4.891**
			1:3 with ♅	**247.94/252.969**	**5.029**
Ixion	756.9 X 684.9 km[4]	251.11 yrs	2:17 with ♄	502.22/500.771	1.449
			1:3 with ♅	251.11/252.969	1.859
			1:21 with ♃	251.11/249.09	2.02
			2:3 with ♆	502.22/494.37	7.85

** These numbers are generated by multiplying the years orbiting the sun for each part of the resonance. Using the example of the 3:25 resonance Orcus has with Saturn, the first number is 3 X 245.19 (Orcus's orbit in years), and the second is 25 X 29.4571 (Saturn's orbit in years). You can then compare both numbers (735.57/736.427) to see how close the resonance is. To help further, the last column specifies the difference between the two numbers.*

As you can see, Pluto is more closely resonant with Neptune than the other two, but Orcus and Ixion are definitely in range, and astronomers agree that all three are resonant with Neptune. However, notice that Orcus has a closer resonance with Saturn, and Ixion also has closer resonances with Saturn, Uranus, and Jupiter than it does with Neptune. Neptune still contributes a definite push, but these other bodies seem even more connected with the bigger planets that orbit farther away from them. Later we will return to this point, as it may give us invaluable clues in determining these objects' meaning. And don't panic seeing all this math. Very soon you will see everything fall into place and be much simpler.

Pluto is not the only large dwarf to have companions. Haumea also has a few co-orbiting cohorts:

Name	Diameter	Orbits Sun	Resonance	How Closely Resonant?	Difference
Varuna	668 (+154/-86) km[5]	279.21 yrs	3:10 with ♅	837.63/843.23	5.6
			3:71 with ♃	837.63/842.188	4.558
			2:19 with ♄	558.42/559.685	1.265
			7:12 with ♆	1954.47/1977.48	23.01
2002 TX_{300}	145 ±5 km[6]	283.12 yrs	1:24 with ♃	283.12/284.683	1.563
			7:12 with ♆	1981.84/1977.48	4.36
			3:10 with ♅	849.36/843.23	6.13
			2:19 with ♄	566.24/559.685	6.555
Haumea	**2100 X 1680 X 1074 km[7]**	**283.12 yrs**	**1:24 with ♃**	**283.12/284.683**	**1.563**
			7:12 with ♆	**1981.84/1977.48**	**4.36**
			3:10 with ♅	**849.36/843.23**	**6.13**
			2:19 with ♄	**566.24/559.685**	**6.555**
Quaoar	1138 (+48/-34) - 1036 (+44/-31) km[8]	288.83 yrs	1:24 with ♃	288.83/284.683	1.217
			1:10 with ♄	288.89/294.57	8.67
			3:10 with ♅	866.49/843.23	14.47
			7:12 with ♆	2021.81/1977.48	44.33

Just like with Pluto's family, Varuna, Quaoar, and the small but very bright 2002 TX_{300} appear close in period to Haumea's orbit, but each has closer resonance with various gas giants, and except perhaps Haumea, none is very closely resonant with Neptune.[9] All are in closest resonance with Jupiter and/or Uranus. (Shaded table cells indicate relationships that are a bit far for resonance.)

Makemake does not have really close sizeable neighbors like Pluto and Haumea have, but it has an interesting one, resonance-wise, that is relatively close:

Name	Diameter	Orbits Sun	Resonance	How Closely Resonant?	Difference
Makemake	**1502 (±45) X 1430 (±9) km**[10]	**306.21 yrs**	**1:26 with ♃**	**306.21/308.43**	**2.22**
			2:21 with ♄	**612.42/618.599**	**6.179**
			3:11 with ♅	**918.63/927.55**	**8.92**
			1:2 with ♆[11]	**306.21/328.58**	**23.38**
2002 AW_{197}	768 ±39 km[12]	322.65 yrs	1:11 with ♄	322.65/324.02	1.37
			1:27 with ♃	322.65/320.22	2.43
			6:23 with ♅	1935.9/1939.429	3.529
			1:2 with ♆	322.65/329.58	6.93

Eris has a co-orbital buddy, but while their orbits are "close" in the number of years they travel around the sun, both have such eccentric orbits that they often inhabit vastly different areas of the solar system and have not been conjunct for many millennia:

Name	Diameter	Orbits Sun	Resonance	How Closely Resonant?	Difference
Gonggong (2007 OR_{10})	1230 ±50 km[13]	554.37 yrs	1:47 with ♃	554.37/557.05	2.68
			1:19 with ♄	554.37/559.6849	5.3149
			2:13 with ♅	1108.74/1096.199	12.541
			3:10 with ♆	1663.11/1647.90	15.21
Eris	**2326 ±12 km**[14]	**559.07 yrs**	**1:19 with ♄**	**559.07/559.6849**	**0.6149**
			1:47 with ♃	**559.07/557.505**	**1.565**
			5:17 with ♆	**2795.35/2801.43**	**6.08**
			3:20 with ♅	**1677.21/1686.46**	**9.25**

Now, excluding Sedna, since there are estimation problems with that object's orbit, let's see what all that math boils down to (numbers modified to better include some large "difference" overages):

Dwarf or Group	♆ Resonance	♅ Resonance	♄ Resonance	♃ Resonance
Orcus	2:3	1:3	3:25	1:21
Pluto & Ixion	2:3	1:3	2:17	1:21
Varuna	7:12	3:10	2:19	3:71
Haumea & TX_{300}	7:12	3:10	2:19	1:24
Quaoar			1:10	1:24
Makemake	1:2	3:11	2:21	1:26
AW_{197}	1:2	6:23	1:11	1:27
Gonggong (OR_{10})	3:10	2:13	1:19	1:47
Eris	5:17	3:20	1:19	1:47

All those numbers don't look related, except perhaps for a bumpy progression in the Jupiter resonances. What if we multiplied some of those smaller numbers, so they matched their neighbor numbers more closely? We aren't changing the values; we're just changing the form so we might detect a pattern. For example, another way to write 2:3 is 8:12. The latter reduces to 2:3 if you divide both sides by 4. Below shows how some numbers are being changed in form only:

Dwarf or Group	♆ Resonance	♅ Resonance	♄ Resonance	♃ Resonance
Orcus	2:3 = 8:12	1:3 = 3:9	3:25 = 2:16.66	1:21
Pluto & Ixion	2:3 = 8:12	1:3 = 3:9	2:17	1:21
Varuna	7:12	3:10	2:19	3:71 = 1:23.66
Haumea & TX_{300}	7:12	3:10	2:19	1:24
Quaoar			1:10 = 2:20	1:24
Makemake	1:2 = 5:10 = 6:12	3:11	2:21	1:26
AW_{197}	1:2 = 5:10 = 6:12	6:23 = 3:11.5	1:11 = 2:22	1:27
Gonggong (OR_{10})	3:10	2:13 = 3:19.5	1:19 = 2:38	1:47
Eris	5:17	3:20	1:19 = 2:38	1:47

So what exactly does this do for us?

<table>
<tr><th>Dwarf or Group</th><th colspan="2">♆ Resonance</th><th>♅ Resonance</th><th>♄ Resonance</th><th>♃ Resonance</th></tr>
<tr><td>Orcus</td><td colspan="2">8:12</td><td>3:9</td><td>2:16.66</td><td>1:21</td></tr>
<tr><td>Pluto & Ixion</td><td colspan="2">8:12</td><td>3:9</td><td>2:17</td><td>1:21</td></tr>
<tr><td>Varuna</td><td colspan="2">7:12</td><td>3:10</td><td>2:19</td><td>1:23.66</td></tr>
<tr><td>Haumea & TX_{300}</td><td colspan="2">7:12</td><td>3:10</td><td>2:19</td><td>1:24</td></tr>
<tr><td>Quaoar</td><td colspan="2"></td><td></td><td>2:20</td><td>1:24</td></tr>
<tr><td>Makemake</td><td>5:10</td><td>6:12</td><td>3:11</td><td>2:21</td><td>1:26</td></tr>
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</table>

Now if you scan down each column, virtually all the numbers appear to follow a sequence. In the Jupiter column, for example, note how just one orbit of each of these objects is timed with a number of Jupiter orbits, and between each groupings, there's a gap usually equal to one or two Jupiter orbits. The same is true with Saturn, except that for every two orbits of Pluto/Ixion, Varuna/TX_{300}/Haumea, Quaoar, Makemake, and AW_{197}, Saturn makes 17, 19, 20, 21, and 22 orbits respectively. Now look at Uranus vs. the Dwarfs. For every three orbits of Pluto and co., Varuna/TX_{300}/Haumea, and Makemake, Uranus makes 9, 10, and 11 orbits respectively around the sun. To recap, that's one orbit per a number of Jupiter orbits; two orbits per a number of Saturn orbits; and three orbits per some Uranus orbits, except note that in Uranus's case, the orbits increase by just one. Just ignoring the Neptune column for now, you might theorize that no *large* dwarfs can stabilize between these groupings, because Uranus won't let that happen. There's room as far as Jupiter and Saturn are concerned, perhaps, but Uranus only lets something a little smaller, like AW_{197} and Gonggong, hang out at an exception resonance, which in their cases is 3:11.5 and 3:19.5 respectively. It could also be that the dominant Dwarf in the area knocks its smaller neighbors into these spots; notice how Orcus is slightly off the rest of its group resonance with Saturn (2:16.66), and Varuna is slightly off its group resonance with Jupiter (1:23.66).

If you noticed that Quaoar appears to lack close connection with Neptune and Uranus, the explanation given for that is Quaoar's orbit is so circular, with a low eccentricity of .039, that Neptune hardly perturbs it (and therefore is not a factor in resonance).[15] Uranus and Neptune are about the same size, so if the nearer Neptune has little impact, Uranus would have even less.

Eris (and Gonggong) are twice as far from the sun as Pluto is, so naturally there's a huge jump in their resonance particulars. But see how, even with that jump, Eris (and for the most part, OR_{10} as well) has to "abide" by the 1 orbit per x number of Jupiter orbits, 2 orbits per x no. of Saturn orbits, and 3 orbit per x no of Uranus orbits.

And now we get to Neptune. Neptune totally screws up all the lovely patterns going on with its fellow giants and their cousin dwarfs. Why is that? For one thing, Neptune does not follow another well-known pattern of our solar system structure called the Titius-Bode law. Suffice it to say that if Neptune followed that rule's prediction of the placement of planets (which includes the big bodies in the asteroid belt), Neptune would orbit at Pluto's average distance from the sun. Instead, Neptune orbits halfway between Uranus's orbit and Pluto's average distance. No one is sure why the Titius-Bode law breaks down with Neptune, but it may be that when you get far enough away from the sun, the predicted intervals become so huge that large objects can manage to orbit unperturbed at the halfway points.

Even though Neptune's resonant relationship does not perfectly jive with the others, perhaps you noticed it does display two kinds of patterning. First, remember how we reformulated the Pluto/Neptune resonant relationship of 2:3 to 8:12, so it matched the other groups' Neptune resonances more clearly? Divide that last number by half, and you get 4:6. So Pluto and at least Ixion are 1:21 with Jupiter, 2:17 with Saturn, 3:9 with Uranus, and 4:6 with Neptune. As the second number in the resonance decreases, the first number bumps up by one – nice and regular! Too bad Haumea and Makemake can't follow suit. But there might be a reason that only Pluto (and its nearest neighbors) get the most resonant spot in the Kuiper Belt, so agreeable with all its big brothers: Pluto is the biggest one in its own particular realm, the Kuiper Belt. Eris might be slightly more massive than Pluto, but Eris is only a visitor to the Kuiper Belt; during most of its orbit, Eris is way far out past what's called the Kuiper cliff. Pluto is the Big Boy to be reckoned with in its spacious neck of the woods.

That said, there's an internal pattern in between those Neptune resonances. Put Pluto/Ixion back at 8:12, and you see a descending first number in the rest, with Haumea/Varuna at 7:12, and Makemake/AW_{197} at 6:12. Further than that, it's impossible for the Neptune resonances for Haumea and Makemake to be more agreeable to the pattern we see elsewhere. Neptune is literally not in a position to make that happen.

The upshot of all this resonance stuff is to show you exactly how specific the spots are which the large and medium-sized Dwarf Planets inhabit, as they are actually determined by their big gaseous siblings orbiting closer to the sun. While astronomers and planetary scientists usually expect that Neptune corrals these objects into some kind of stability, doesn't it make sense that the other three would also have a "say"? Especially considering that the gas giants get larger the farther towards the inner solar system you go, ending with Jupiter, which is more massive than all the other planets combined, and that includes Saturn, too. The bigger you are, the stronger your gravitational pull. It's also gratifying to see how all these celestial objects are really connected to one another, since with astrology, it's all about connections. When we run charts, we see a timing connection between planetary movements and our clients' life events, and if we obtain the necessary additional birth data, we can see the timing connections between those same clients' lives and the lives of their loved ones, their friends, intimate family members, even complete strangers with whom they become inadvertently involved (like in a car accident). So why wouldn't there be a complete web of connections between all the planets of our solar system?

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[1] http://arxiv.org/abs/1305.0449

[2] This shouldn't count as resonance as Jupiter has a "short" 12-year orbit. Being off by four years is too much, but included for the curious.

[3] Nimmo, Francis; et al. (2017). "Mean radius and shape of Pluto and Charon from New Horizons images." *Icarus*. **287**: 12–29.

[4] Levine, Stephen E.; Zuluaga, Carlos A.; Person, Michael J.; Sickafoose, Amanda A.; Bosh, Amanda A.; Collins, Michael (April 2021). "Occultation of a Large Star by the Large Plutino (28978) Ixion on 2020 October 13 UTC". *The Astronomical Journal*. **161** (5): 210.

[5] http://en.wikipedia.org/wiki/20000_Varuna

[6] Elliot, J. L.; Person, M. J. et al. (2010). "Size and albedo of Kuiper belt object 55636 from a stellar occultation." *Nature* **465** (7300): 897–900. Bibcode:2010Natur.465..897E. doi:10.1038/nature09109 . Also, it is not a typo that Haumea and 2002 TX_{300} have identical orbit lengths. TX_{300} is a fragment of Haumea that broke off during a collision in the distant past and now orbits mostly opposite Haumea.

[7] Dunham, E. T.; Desch, S. J.; Probst, L. (April 2019). "Haumea's Shape, Composition, and Internal Structure". *The Astrophysical Journal*. **877** (1): 11.

[8] https://en.wikipedia.org/wiki/50000_Quaoar

[9] At least not by the astronomers updating Wikipedia, e.g., http://en.wikipedia.org/wiki/Quaoar

[10] Ortiz, J. L.; Sicardy, B.; Braga-Ribas, F.; Alvarez-Candal, A.; Lellouch, E.; Duffard, R.; Pinilla-Alonso, N.; Ivanov, V. D.; Littlefair, S. P.; Camargo, J. I. B.; Assafin, M.; Unda-Sanzana, E.; Jehin, E.; Morales, N.; Tancredi, G.; Gil-Hutton, R.; De La Cueva, I.; Colque, J. P.; Da Silva Neto, D. N.; Manfroid, J.; Thirouin, A.; Gutiérrez, P. J.; Lecacheux, J.; Gillon, M.; Maury, A.; Colas, F.; Licandro, J.; Mueller, T.; Jacques, C.; Weaver, D. (2012). "Albedo and atmospheric constraints of dwarf planet Makemake from a stellar occultation". *Nature*. **491** (7425): 566–569.

[11] Wikipedia claims 6:11 resonance but that yields a difference of 24.57. Curious that 1:2 wouldn't be more attractive, with a similar but smaller 23.38 difference. Co-discoverer Mike Brown maintains Makemake's Wikipedia page, and so I assume 6:11 is his notation.

[12] Vilenius, E.; Kiss, C.; Müller, T.; Mommert, M.; Santos-Sanz, P.; Pál, A.; et al. (April 2014). ""TNOs are Cool": A survey of the trans-Neptunian region. X. Analysis of classical Kuiper belt objects from Herschel and Spitzer observations". *Astronomy and Astrophysics*. **564**: 18.

[13] Kiss, C.; Marton, G.; Parker, A. H.; Grundy, W.; Farkas-Takacs, A.; Stansberry, J.; et al. (December 2019). "The mass and density of the dwarf planet (225088) 2007 OR_{10}". *Icarus*. **334**: 3–10.

[14] https://en.wikipedia.org/wiki/Eris_(dwarf_planet)

[15] http://en.wikipedia.org/wiki/50000_Quaoar