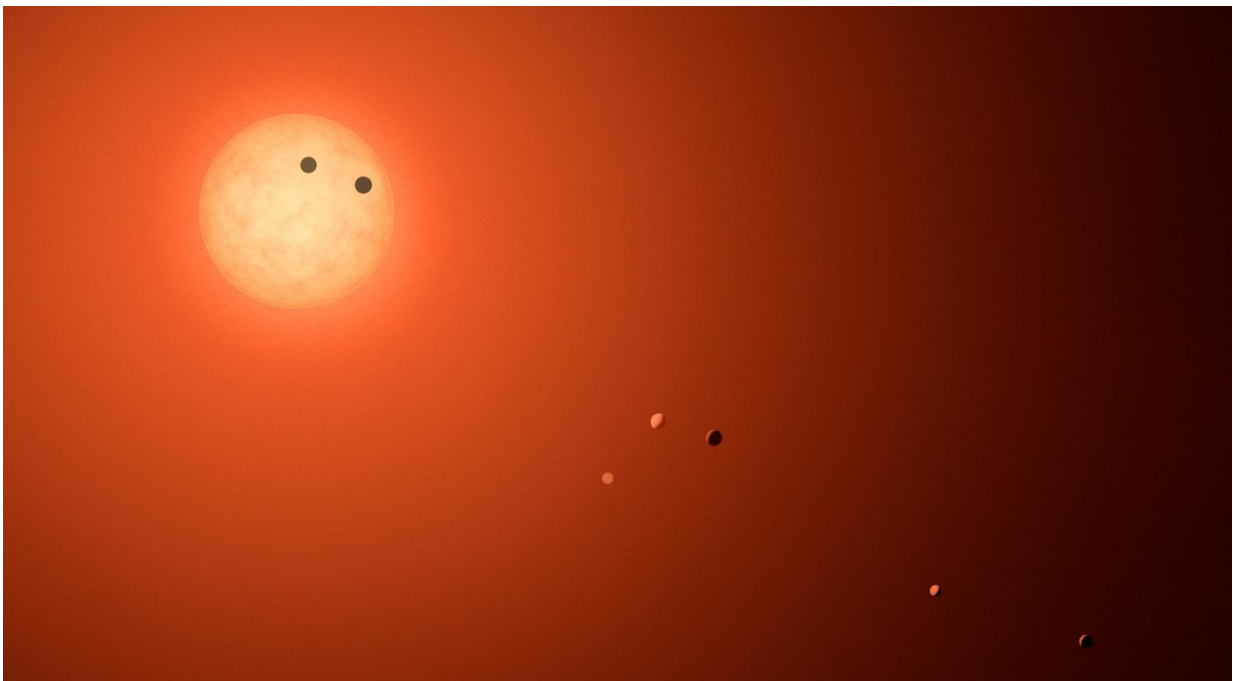


Astrophysicists find that planetary harmonies around TRAPPIST-1 save it from destruction

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Artist's rendering of seven Earth-sized planets orbiting TRAPPIST-1. Credit: NASA

When NASA announced its discovery of the TRAPPIST-1 system back in February it caused quite a stir, and with good reason. Three of its seven Earth-sized planets lay in the star's habitable zone, meaning they may harbour suitable conditions for life.

But one of the major puzzles from the original research describing the system was that it seemed to be unstable.

"If you simulate the system, the [planets](#) start crashing into one another in less than a million years," says Dan Tamayo, a postdoc at U of T Scarborough's Centre for Planetary Science.

"This may seem like a long [time](#), but it's really just an astronomical blink of an eye. It would be very lucky for us to discover TRAPPIST-1 right before it fell apart, so there must be a reason why it remains stable."

Tamayo and his colleagues seem to have found a reason why. In research published in the journal *Astrophysical Journal Letters*, they describe the planets in the TRAPPIST-1 system as being in something called a "resonant chain" that can strongly stabilize the system.

In resonant configurations, planets' orbital periods form ratios of whole numbers. It's a very technical principle, but a good example is how Neptune orbits the Sun three times in the amount of time it takes Pluto to orbit twice. This is a good thing for Pluto because otherwise it wouldn't exist. Since the two planets' orbits intersect, if things were random they would collide, but because of resonance, the locations of the planets relative to one another keeps repeating.

"There's a rhythmic repeating pattern that ensures the system remains stable over a long period of time," says Matt Russo, a post-doc at the Canadian Institute for Theoretical Astrophysics (CITA) who has been working on creative ways to visualize the system.

TRAPPIST-1 takes this principle to a whole other level with all seven planets being in a chain of resonances. To illustrate this remarkable configuration, Tamayo, Russo and colleague Andrew Santaguida created an animation in which the planets play a piano note every time they pass

in front of their host star, and a drum beat every time a planet overtakes its nearest neighbour.

Because the planets' periods are simple ratios of each other, their motion creates a steady repeating pattern that is similar to how we play music. Simple frequency ratios are also what makes two notes sound pleasing when played together.

Speeding up the planets' orbital frequencies into the human hearing range produces an astrophysical symphony of sorts, but one that's playing out more than 40 light years away.

"Most planetary systems are like bands of amateur musicians playing their parts at different speeds," says Russo. "TRAPPIST-1 is different; it's a super-group with all seven members synchronizing their parts in nearly perfect time."

But even synchronized orbits don't necessarily survive very long, notes Tamayo. For technical reasons, chaos theory also requires precise orbital alignments to ensure systems remain stable. This can explain why the simulations done in the original discovery paper quickly resulted in the planets colliding with one another.

"It's not that the system is doomed, it's that stable configurations are very exact," he says. "We can't measure all the orbital parameters well enough at the moment, so the simulated systems kept resulting in collisions because the setups weren't precise."

In order to overcome this Tamayo and his team looked at the system not as it is today, but how it may have originally formed. When the system was being born out of a disk of gas, the planets should have migrated relative to one another, allowing the system to naturally settle into a stable resonant configuration.

"This means that early on, each planet's orbit was tuned to make it harmonious with its neighbours, in the same way that instruments are tuned by a band before it begins to play," says Russo. "That's why the animation produces such beautiful music."

The team tested the simulations using the supercomputing cluster at the Canadian Institute for Theoretical Astrophysics (CITA) and found that the majority they generated remained stable for as long as they could possibly run it. This was about 100 times longer than it took for the simulations in the original research paper describing TRAPPIST-1 to go berserk.

"It seems somehow poetic that this special configuration that can generate such remarkable music can also be responsible for the [system](#) surviving to the present day," says Tamayo.

Provided by University of Toronto

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