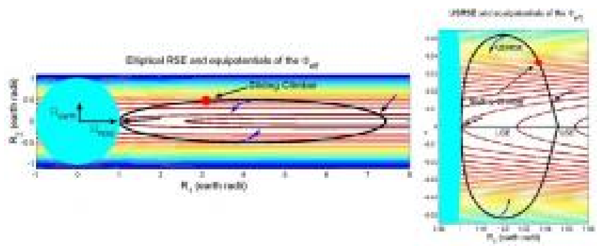
Rotating Space Elevator Propels its Own Load

May 21 2009, by Lisa Zyga



(Left) A rotating space elevator and (right) a uniform stress rotating space elevator (an RSE combined with an LSE). The rotating systems can propel “sliding climbers” up the loops using the centrifugal force, similar to how stirred coffee can rise and splash out of a cup. Image credit: Golubović and Knudsen.

(PhysOrg.com) -- The idea of the space elevator just got a little crazier. While the “traditional” concept involved using rocket propulsion or laser light pressure to propel loads up a cable anchored to Earth, a new study shows that a rotating space elevator could do away with engines or laser light pressure application completely. Instead, the unique double rotating motion of looped strings could provide a mechanism for objects to slide up the elevator cable into outer space. The space elevator could launch satellites and spacecraft with humans, and even be used to host space stations and research posts.

Ever since Konstantin Tsiolkovsky first proposed the idea of a giant string connecting the Earth and the heavens in 1895, scientists and sci-fi writers alike have been intrigued. But it seems no one has yet suggested that a space elevator could propel its own load, without the need for internal engines, laser light pressure, or any kind of propulsion. In a recent study funded in part by NASA, theoretical physicist Leonardo Golubović and his graduate student Steven Knudsen at West Virginia University have explained that this concept is possible, at least in theory.

Golubović and Knudsen have introduced the Rotating Space Elevator (RSE), a rotating system of a floppy string that forms an ellipse-like shape. Unlike the traditional Linear Space Elevator (LSE) made of a single straight cable at rest, the RSE rotates in a quasi-periodic state. As the scientists explain, RSE motion is nearly a geometrical superposition of two components: its geosynchronous rotation around Earth (which has a one-day period), and the internal rotation of the string system that goes on around the axis perpendicular to the Earth (about a 10-minute period). This internal rotation of the string is especially important, as it provides a mechanism for objects to freely slide along the string, and also provides the dynamical stability to maintain the elevator shape.

“The idea came by itself,” Golubović told *PhysOrg.com*. “I was thinking how to make things move easily and quickly up the traditional Tsiolkovsky-type space elevators. In my kitchen, I was mixing coffee in my cup too vigorously and the centrifugal force on the rotating coffee won over gravity to make some of the coffee lift and splash out the cup. This was my ‘eureka’ that lead to adding a similar conceptual feature to the old space elevator idea, the internal rotation. Indeed, much like the coffee would lift and splash out the cup if rotated fast enough, the climbers on our Rotating Space Elevator will be lifted up by the centrifugal force winning over gravity.”

Like the LSE, the RSE is attached to the Earth to provide loading access. To initiate the double rotational motion, the string system is given an initial spin. Other than this initial spin, the RSE moves purely under the influence of inertia and gravity. In simulations, Golubović and Knudsen show how a load starting at rest near the Earth spontaneously oscillates between its starting point near Earth and a turning point in outer space (close to the top of the string). Using a specially chosen variation of the tapered elevator cable cross-sectional area, the scientists could ensure that the RSE string will indefinitely maintain its initial looped shape. Golubović said that, as far as he knew, this type of motion does not occur in any other areas of physics or astronomy.

"There are no known astronomical size solid (or floppy) objects that are shaped as strings," he said. "It thus remains for humans to make them. As stated by a referee of our paper 'No one is an expert on the ideas displayed in this paper.' At this moment, the only judge is pure mathematics and it shows that our RSE can work, in a fascinating fashion."

Golubović and Knudsen also proposed a slightly different form of the RSE, which combines an RSE with an LSE (an ellipse-like rotating string is attached to a linear string). This "uniform stress RSE" (USRSE) could be designed with its loop positioned above the Earth's surface, which might have advantages for launching satellites. The scientists also show that stacking several USRSE loops could create pathways reaching deeply into outer space, and loads could cross from string to string at intersection points.

Through simulations, the scientists investigated the effects of changing the initial period of the RSE. They found that this alteration causes a phase transition, creating tension that causes the elliptical RSE shape to narrow into two linear-type space elevators that fluctuate nearly independently. Over a period of two weeks, the RSE's angular momentum decays to zero, causing the RSE top to drift away from its initial position to a higher position around which the RSE top continues to oscillate in a chaotic fashion.

When asked how far away current technology is from actually building space elevators or rotating space elevators, Golubović was hopeful. “Our USRSE is technologically not more demanding than the traditional space elevator that can be indeed made to stand high tensile pressure by using the existing carbon nanotube composite materials,” he said. “I hope my children or grandchildren will see both the traditional and rotating space elevator one day, if not on the Earth than on other planets such as Mars, which is free of man-made space debris that can hurt space elevators.

“Moreover, some new and related ideas may come up soon to aid space elevator technology. It’s not all about materials being used but rather about structures being employed and new ideas being propagated. The very concept of ‘simple rotation’ is not so simple as commonly thought. Our RSE is a good example of this within the non-relativistic theory of inertia and gravity. Other fascinating examples involve rotating black holes in general relativity that are (theoretically) known to act as time machines. Fortunately, unlike the black holes, the non-relativistic physics of our rotating space elevator is within modern-day technology limits.”

More information: L. Golubović and S. Knudsen. “Classical and Statistical mechanics of celestial-scale spinning strings: Rotating space elevators.” *Europhysics Letters*, 86 (2009) 34001. doi: 10.1209/0295-5075/86/34001.

Citation: Rotating Space Elevator Propels its Own Load (2009, May 21) retrieved 27 April 2024