LETTER TO THE EDITOR

Based on a presentation made at the 89th Spring Meeting of the AAVSO, April 15, 2000

"A Very Low Frequency Gravitational Wave Antenna"

The first gravity wave antenna was built by Joseph Weber at the University of Maryland. It was a massive aluminum bar with a resonance at about 1200 Hz. A gravity wave of that frequency would vibrate the bar at that frequency and a sensor would record the signal. Modern antennas are separated masses with a laser to measure the distance between them; they are not resonant antennas like the original Weber antenna. My antenna has separated masses but they are connected by a spring, so it is a resonant antenna.

Gravity waves are a tidal force so are more easily understood by comparing them with the more familiar tidal force of the Moon that raises the tides in the Earth's oceans. An observer at a given place on the Earth sees a high tide when the Moon is overhead and another 12 hours later when the Moon is on the other side of the Earth. The cause of this tidal effect is the stretching of the Earth's gravitational field into an ellipse by the Moon through the addition of its own gravitational pull to that of the Earth's, with more pull added directly beneath the Moon than on the far side of the Earth. This gradient in the lunar gravity is the tidal force that raises the tides.

Two separated masses, Figure 1, respond to the Moon's gravity the same way the oceans respond. They are pulled apart or squeezed together depending on how they are lined up with the Moon. They are in effect, a tide detector.

Figure 1 shows the Moon in three different locations in relation to the axis of the antenna. When the Moon is in position A along the antenna's axis the Moon's tidal force pulls the masses apart. Six hours later it is in position B and squeezes them together. Another six hours brings the Moon to position C again along the axis and they are pulled apart. To say that the masses are squeezed together in position B may seem counterintuitive to people who think of the low tide as the absence of high tide, who in effect are thinking of the tidal force as being dipole, like the familiar electromagnetic force. In fact, the tidal force—gravity—has only one polarity, positive, so it is a quadropole force. The gravity wave antenna is a true antenna but it responds to a mechanical force that is quadropole.

The changes the Moon makes in the distance between the masses of my antenna are real but cannot be measured. Temperature effects are many magnitudes greater. The spring sets the antenna's resonant frequency that can be tuned between 0.1 Hz and about 0.01 Hz; it is only an efficient antenna within its tunable resonance range. I have described a method of tuning (Hossfield, C. 1994, *J. Amer. Assoc. Var. Star Obs.* **23**, 1, 74) that is similar to the way I tune my present antenna. Lengthening the spring lowers the frequency. It is a high-Q device and needs to be tuned exactly to the frequency of the source that may be a pair of neutron stars or black holes in a binary orbit with a period half the frequency the antenna is tuned to. The chance of such a source being within the sensitivity range

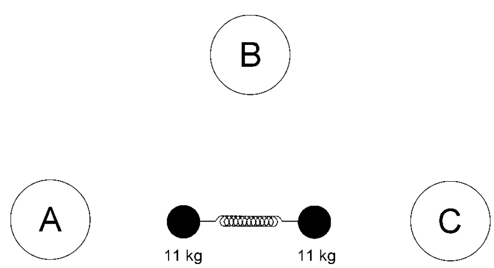

Figure 1. A schematic of my gravity wave antenna, two 11-kg masses floated in the Earth's gravitational field as long period horizontal pendulums that are connected with a spring. A, B, and C are positions of the Moon.

of my antenna is very slim if it exists at all. This does not discourage me. I built my first VLF antenna in 1990 and was so fascinated by how well the design worked that I have continued to build and improve the antenna ever since. I like to design and build things and one of the requirements of the antenna is a long period pendulum to float the masses and also put tension on the spring between them. This is not an easy thing to do. I find no device in the literature on pendulums that will do the job so I invented one (Hossfield, C. 1996, *J. Amer. Assoc. Var. Star Obs.* **24**, 1, 65). I have improved the design and constructed a small working model of my horizontal-swinging long-period pendulum. Figure 2 is a picture of the frame for a much larger pendulum I am building on my farm. The frame is 16 feet high and sits in an excavation that sometimes fills with water. This pendulum is the eastern of the pair. The other pendulum is 300 feet to the west. The west pendulum also sits in an excavation but it does not fill with water. Actually the water is not a problem since the only thing at the bottom of the frame is the lower pivot point for the pendulum. I have made this of stainless steel and brought the stainless steel support wire out where it is always above the water level so I can fasten to the horizontal pendulum beam.

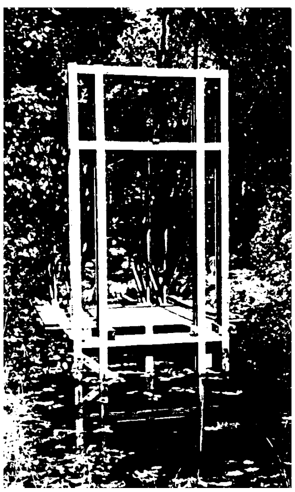

Figure 2. The frame for one pendulum of a large gravity wave antenna. The 16-foot high frame is set in an excavation 7 feet deep so the pendulum will swing horizontally 1 foot above ground level. The excavation is shown here filled with water after a storm.

A signal I might hope to record could come from a pair of neutron stars with an orbital period of 16 seconds. I would have to tune the antenna to 0.03 Hz to resonate with the signal. The binary system would be 12 years from final coalescence and it would be radiating 10^{41} erg/sec as gravity waves, a lot of energy compared to the 10^{33}erg/sec total energy radiated by the Sun as light and heat. The signal would be steady and would still be there years later so others would have time to confirm it. There would be no need to detect it simultaneously on more than one antenna as is the case with antennas that detect the final high-energy pulse that only lasts a few seconds when the stars coalesce.

High frequency gravity wave antennas are built to record this powerful final coalescence signal. During the last second the radiated energy is 10^{51} erg/sec at a frequency above 1000 Hz. This final coalescence is thought to also be the source of gamma ray bursts. Million-dollar high frequency antennas have searched for a final coalescence signal for over 20 years but never detected one. As an amateur I would be foolish indeed to build a high frequency antenna. As far as I know, no one, amateur or professional, has built a low frequency antenna for this purpose. I will search for a signal where no one has ever searched before. If I find nothing I'll be in good company and have wasted only a few hundred dollars of my own money.

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