CENTRIPETAL FORCE & GRAVITY

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LIGO Detects Fierce Collision of Neutron Stars for the First Time

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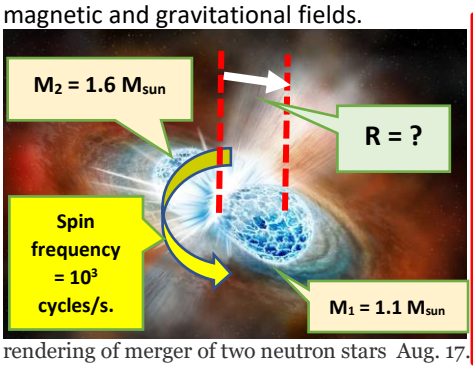
Astronomers announced on Monday that they had seen and heard a pair of dead stars collide, giving them their first glimpse of the violent process by which most of the gold and silver in the universe was created. The collision, known as a kilonova, rattled the galaxy in which it happened 130 million light-years from here in the southern constellation of Hydra, and sent fireworks across the universe. On Aug. 17, the event set off sensors in space and on Earth, as well as producing a loud chirp in antennas designed to study ripples in the cosmic fabric. These stars are masses as great as the sun packed into a region the size of Manhattan brimming with magnetic and gravitational fields.



rendering of merger of two neutron stars Aug. 17.

INTRODUCTION: ***Gravity supplies required centripetal force*** to keep these two neutron stars spinning about their center of mass of 2.7 M_{sun} = M_{cm} .

$GM_1M_{cm}/R^2=M_1V^2/R$, $V = R\omega$, $R2\pi f$, $2\pi R/T$. Thus, **$M_{cm} =[4\pi^2/G][R^3/T^2]$**

G = gravitational constant = 6.67 X 10^{-11} $Nm^2/kg.^2$, T = period = 1/f = 1/ frequency

M_{sun} = 2 X 10^{30} kg. , M_{cm} = center of mass mass = 1.1 M_{sun} + 1.6 M_{sun} = 2.7 M_{sun}

QUESTIONS: (a) Find distance (in meters)to center of mass (R) of these two neutron stars rotating about each other at 1000 cycles/s.?, (b) Find R in miles?

Studying the fireball from this explosion, astronomers have concluded that it had created a cloud of gold dust many times more massive than the Earth, confirming kilonovas as agents of ancient cosmic alchemy. "For the first time ever, we have proof," said Vicky Kalogera, an astronomer at Northwestern University. She was one of thousands of astronomers that reported their results Monday in a globe-girdling set of news conferences and academic conferences. A blizzard of papers is being published, including one in Astrophysical Journal Letters that has some 4,000 authors .

An artist's rendering of a neutron star compared To skyline of Chicago. Neutron stars are about 12 miles in diameter and are extremely dense.

HINTS: 1.62 km. = 1 mile ,

ANSWERS: (a) R = 20.9 km. , (b) R = ~ 12.9 miles

COMMENT: What was unique about this collision was it was observable with many different types of telescopes and gravitational waves were produced. In 2015 gravitational waves were first detected from colliding black holes. But, black holes are not visible. Gravity waves + visible = neutron star collisions.

This is the story of a gold rush in the sky. It began on the morning of Aug. 17, Eastern time. Dr. Shoemaker was on a Skype call when alarms went off. One of the LIGO antennas, in Hanford, Wash., had recorded an auspicious signal and sent out an automatic alert. Twin antennas, in Washington and Livingston, Louisiana, monitor the distance between a pair of mirrors to detect the submicroscopic stretching and squeezing of space caused by a passing gravitational wave. Transformed into sound, the Hanford signal was a long 100-second chirp, that ended in a (((**sudden whoop to 1000 cycles per second**))), two octaves above middle C. Such a high frequency indicated that whatever was **zooming around** was lighter than a black hole.

The merging **objects were probably survivors of stars that had been orbiting each other** and had each puffed up and then died in the supernova explosions in which massive stars end their luminous lives some 11 billion years ago, according to an analysis by Dr. Kalogera. Making reasonable assumptions about their spins, **(((these neutron stars were about 1.1 and 1.6 times as massive as the sun)))** smack in the known range of neutron stars. **(((As they approached each other swirling a thousand times a second)))**, tidal forces bulged their surfaces outward. Quite a bit of what Dr. Metzger called "neutron star guts" were ejected and formed a fat doughnut around the merging stars. According to the LIGO measurements, **it was about as massive as 2.6 suns.** Scientists say that for now they are unable to tell whether it collapsed straight into a black hole, formed a fat neutron star that hung around in this universe for a few seconds before vanishing, or remained as a neutron star.