CENTRIPETAL FORCE & GRAVITY

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Gravitational Waves Detected, Confirming Einstein's Theory

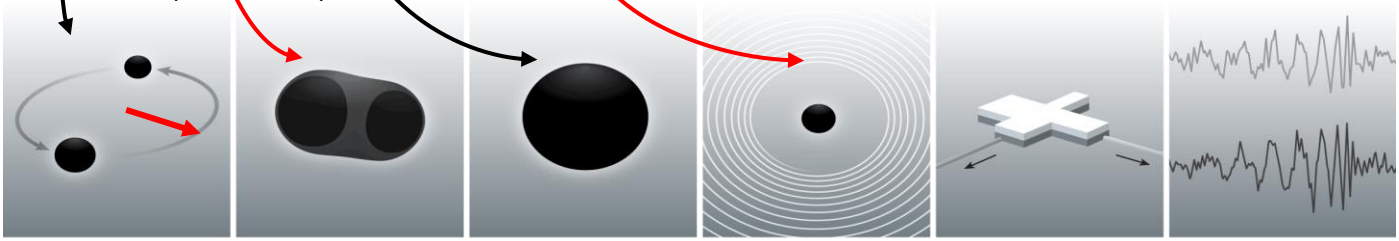
LIGO Hears Gravitational Waves Einstein Predicted

About a hundred years ago, Einstein predicted the existence of gravitational waves, but until now, they were undetectable. A team of scientists announced on Thursday that they had heard and recorded the sound of two black holes colliding a billion light-years away, a fleeting chirp that fulfilled the last prediction of Einstein's general theory of relativity. On Sept. 14, the system had barely finished being calibrated and was in what is called an engineering run at 4 a.m. when a loud signal came through at the Livingston site. "Data was streaming, and then 'bam,' " recalled David Reitze, a Caltech professor who is the director of the LIGO Laboratory, the group that built and runs the detectors.**(((One of them was 36 times as massive as the sun, the other 29. As they approached the end, at half the speed of light, they were circling each other 250 times a second.And then the ringing stopped as the two holes coalesced into a single in space with the equivalent mass of 62 suns.))) All in a fifth of a second, Earth time** **Hearing a Gravitational Wave** Predicted by Einstein's general theory of relativity 100 years ago, gravitational waves have been directly detected for the first time. LIGO, the Laser Interferometer Gravitational-Wave Observatory, heard black holes colliding.

TWO BLACK HOLES:About 1.2 billion years ago in a distant galaxy, a pair of black holes circled each other. The larger black hole was 36 times the mass of our sun, and the smaller one 29 times.

COLLISION: The intense gravity accelerated the black holes to half the speed of light, pulling them closer and carving distortions in space and time. In a fraction of a second, the pair collided and merged into an irregular shape.

RING DOWN:The unstable blob smoothed into a sphere, a process called ring down. Three solar masses' worth of energy were vaporized in a storm of gravitational waves, distorting space and time and leaving a new black hole 62 times the mass of the sun.**GRAVITATIONAL WAVES:**The invisible waves rippled outward at the speed of light. But waves fade with distance, and when they finally reached Earth, the distortions were too small to be measured above the heat, noise and other vibrations of our planet. **DETECTION**: LIGO is a pair of L-shaped observatories 1,900 miles apart. Ultra-pure mirrors at the ends of each arm are isolated from vibrations. Passing gravitational waves push and pull the arms, changing the length of tunnels by less than the width of a proton. **A CHIRP:** On Sept. 14, LIGO's detectors measured their first vibrations from a gravitational wave. Translated to sound, it was a short chirp, the billion-year-old echo of the collision of those two black holes.



INTRODUCTION: Gravity supplies force to bind two black holes: G Mm/R^2 = m V^2/R, with V = Rω = 2 πR f = 2πR/T , yielding M =[4π^2/G](R^3/T^2) . Where (from article above) M = 65 solar masses. And: G = 6.67 X 10 $^{-11}$ N m^2/kg.^{2} , T = 1/f Where f = 250 cycles/s. Purpose of this application is to find R(radius of two Black holes circling each other) and then linear speed of black holes'

HINTS: Solar mass = 2 X 10^{30} kg. , V = R ω = R 2 π f , speed of light c = 3.0 X 10^8 m./s.

QUESTIONS: (a) Find mass of the two black holes…..65 solar masses?, (b) Find radius (R) of two orbiting black holes?, (c) Find linear speed(V) of black holes orbiting their center of mass?, (d) How does this speed compare to speed of light?

ANSWERS: (a) M = 130 X 10^{30} kg., (b) 1.52 X 10^5 m., (c) V = ~ 2.4 X 10^8 m./s., (d) V = 80% light speed, close to half.