ENERGY CONSERVATION/WORK Unit 16,11

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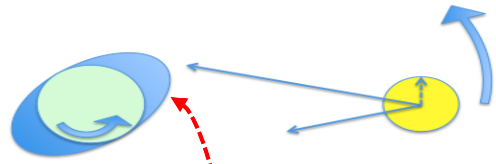
The Moon Is (Slightly) Flat, Scientists Say



Forty-five years after astronauts landed on the moon, scientists say they have finally discovered its true shape: slightly flattened, with a **bulge on one side.** "Like a lemon with an equatorial bulge," said Ian Garrick-Bethell, a planetary scientist at University of California, Santa Cruz, and an author of the study, being published in the journal Nature. "If you can imagine a water balloon flattening out as you spin it." Efforts to pinpoint the moon's exact shape have long been stymied by the presence of large craters on its surface that formed after the crust solidified. There have also been inconsistencies between its measurements and what we know about its past. For example, the moon barely spins, yet it appears to have the sort of equatorial bulge caused by rotation. And why would a giant ball of cooled liquid be anything but spherical? "There's no plate tectonics like on the earth," Dr. Garrick-Bethell said. "Why is it so deformed?" To overcome the crater problem, he and his colleagues used highly accurate maps of the moon's topography, made with a laser altimeter, then ran calculations to see what the surface could have looked like before the **squashed appearance is probably a result of the gravitational process called tidal heating or acceleration, which stretched the moon's crust as it was being formed. The (((equatorial bulge probably dates To a later period ,when the moon was still spinning but was slowing down and Moving away from the earth, freezing a tidal surge in place.)))**

INTRODUCTION: http://CisePhysics.homestead.com/files/MoonMovesAway.pdf for source of data mentioned here. The purpose of this application is to find **earth's rotational kinetic energy lost** in past 600 million years. Most of this energy is lost to tidal friction, but 1/30 is transferred to the moon (see right). The moon's increase in total mechanical energy (E = U + K) from the earth appears in Moon's increase in gravitational potential energy (U). The moon's orbital Kinetic energy actually decreases as is seen.

GIVEN: I_e earth moment of inertia = 9.72×10^{37} kg. m^2 , when earth had a 22 hr. day 600 M yrs. ago. $\omega_{e1} = 0.7933 \times 10^{-4}$ rad./s Now, with 24 hr. day. $\omega_{e2} = 0.729 \times 10^{-4}$ rad./s., moon orbital speed 600 M yrs. ago = $V_{m1} = 10.415 \times 10^2$ m./s. moon orbital speed now = $V_{m2} = 10.225 \times 10^2$ m./s., moon earth distance 600 M yrs. ago = $R_{m1} = 3.713 \times 10^8$ m., moon earth distance now = $R_{m2} = 3.844 \times 10^8$ m.

QUESTIONS A: (a) Find earth's rotational KE 600 M yrs ago? (b) Find earth's rotational kinetic energy now? (c) Find ΔK_{earth}?

ANSWERS A: (a) $K_{e1} = 3.0585 \times 10^{29}$ J , (b) $K_{e2} = 2.5828 \times 10^{29}$ J (c) $\Delta E_{earth} = -0.4757 \times 10^{29}$ J (>97% went into tidal friction work)

HINTS: $K_{rotation} = ½ I \omega^2$, $K_{linear} = ½ m v^2$, $U_{gravitational} = - G M_e M_m / R$ $G = 6.67 \times 10^{-11}$ N m^2/kg.^{2} , $M_e = 6 \times 10^{24}$ kg., $M_m = 7.35 \times 10^{22}$ kg.

QUESTIONS B: (a) Find moon K_{m1} 600 M yrs. ago? (b) Find moon K_{m2} now? (c) Find moon U_{m1} 600 M yrs ago.? (d) Find moon U_{m2} Now? (e)Find ΔK_{moon} ?, (f) Find ΔU_{moon} ? (g) Find $\Delta E(mech.)_{moon}$? (h) Find ratio $\Delta E_{moon}/\Delta E_{earth}$ = ?

ANSWERS B: (a) 3.9862×10^{28} J, (b) 3.842×10^{28} J, (c) -0.792217×10^{29} J , (d) – 0.765219×10^{29} J, (e) – 0.1442×10^{28} J,(f) + 0.27×10^{28} J , (g) + 0.1258×10^{28} J , (h) ~ 0.0264 or 2.64 %

Tidal friction is required to drag and maintain the ***bulge ahead of the Moon, and it dissipates the excess energy of the exchange of rotational and orbital energy between Earth and the Moon as heat.*** If the friction and heat dissipation were not present, the Moon's gravitational force on the tidal bulge would rapidly (within two days) bring the tide back into synchronization with the Moon, and the Moon would no longer recede. Most of the dissipation occurs in a turbulent bottom boundary layer in shallow seas such as the European Shelf around the British Isles, the Patagonian Shelf off Argentina, and the Bering Sea.[14]

The gravitational torque between the Moon and the tidal bulge of Earth causes the Moon to be constantly promoted to a slightly higher orbit(~ +3.8 cm./yr.) and Earth to be decelerated in its rotation. As in any physical process within an isolated system, total energy and angular momentum are conserved. Effectively, energy and angular momentum are transferred from the rotation of Earth to the orbital motion of the Moon (however, ***most of the energy lost by Earth (-3.321 TW) is converted to heat by frictional losses in the oceans and their interaction with the solid Earth, and only about 1/30th (+0.121 TW) is transferred to the Moon)***

NOTE STATED: 1/30(~ 3.33 %)earth's rotational energy goes to the moon. The computed answer at left is quite close…2.64% (-: Physics Happyness