Group Index Card, 11/20

Consider the acceleration of gravity on an object at equivalent distances from stars of different kinds:

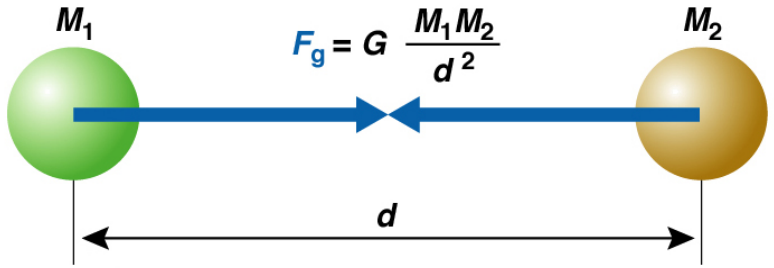
1. An object located 1 A.U. (Earth-Sun distance) from a 1 $M_\odot$ Main Sequence star. Now replace the star with a 1 $M_\odot$ white dwarf. What happens to the gravity? What if you replace it with a 1 $M_\odot$ neutron star?

2. Now place the object at the surface of each star. How does the gravitational acceleration change as you go from a Main Sequence star to a white dwarf (10^{-2} $R_\odot$), and a neutron star (10^{-4} $R_\odot$)? Explain your reasoning. If calculating numbers is too hard, just state the expected change in qualitative terms.

How Gravity Behaves

Its strength is directly proportional to both of the masses, and inversely proportional to the square of the distance between the ***centers*** of the two objects.

The ***acceleration*** of M_1 due to M_2 is this force divided by it own mass, M_1 , so it is given by $a_g = GM_2/d^2$.



Strength of Gravity at 1 A.U.

Three objects, all with the same mass (= 1 $M_\odot$): Main Sequence star, white dwarf, neutron star. The object feeling the gravity is at 1 A.U. in each case.

- "Gravity does not change. You are still the same distance from the center of mass." **Right!**
- "…the same because the mass and distance are the same in all three cases."
- The key here is what we mean by "distance." It is the distance *between the centers, not the surfaces*, of the two objects interacting gravitationally.

Confusions: Gravity at 1 A.U.

Half the class thought that gravity increases when you replace the Main Sequence star with a white dwarf of the same mass & increases further if it's a neutron star.

- "The pull of gravity increases with each new, denser star." Density is not relevant when the object is located far away from the star.
- "When you replace the MS star with a WD, the gravity decreases because the distance increases." The distance from the center is the same: 1 A.U.
- "The acceleration of gravity increases as the object increases in radius." No. Only if the mass increases.

Strength of Gravity at the Surface

2. Now we are talking about an object at the *surface* of each star. So the *distance* changes, because these objects have surfaces of smaller radius which contain the mass: 10^{-2} $R_\odot$ for the WD, 10^{-4} $R_\odot$ for the NS.

- "[The acceleration] increases because the surface is closer to the center of mass."
- "The gravity becomes larger since distance comes into effect... [is smaller], decreasing the denominator in the equation for gravity."
- "acceleration is stronger because the surface is closer to the center of mass."

Confusions: Surface Gravity

Most said that the gravity increases, but relatively few groups correctly explained why. Other confusions:

- "Gravitational acceleration gets slower since their masses are lower." The masses are the same in all cases; the numbers given were for the radii.
- "Gravity becomes weaker as the star mass increases." This is literally wrong, and the mass didn't increase.
- "Gravitational acceleration could decrease because as the radius decreases, the orbit could get larger." The other object is not in orbit, it's at the star's surface.