Astrobiology News May 2016: Walking on Other Worlds

For as long as I can remember, I wanted to be an Astronomer. Three things motivated this desire – science fiction, the space program, and, since I grew up about 10 miles from Manhattan, visiting the Hayden Planetarium in NYC. I recall checking my weight on other worlds using a set of old mechanical scales and wondering what it would be like to move about on the Moon, where I'd weigh only 1/6 of my Earth weight. Not long after, I remember watching the Apollo astronauts and thinking how amazing it would be to bounce across the surface of another world like that!

In most science fiction movies, human beings appear to navigate around on all sorts of planetary surfaces exactly as they would on the Earth. Of course, depicting how people would walk on planets with vastly different surface gravities is difficult to implement, both technically and financially. As it turns out, though, walking around on different alien planets might not be so different from walking around on Earth![1] Curiously, our Solar System contains five worlds with very different environments that have approximately the same surface gravity, and therefore your weight wouldn't change much from world to world. Why is this so?

The surface gravity of a planet increases with a planet's mass and decreases with the square of its radius. This means that if planet A and planet B are the same size, but planet B has twice planet A's mass, planet B's surface gravity will be twice as large; however, if planet A and planet B have the same mass, but planet B's radius is twice as large, planet B's surface gravity will only be one-fourth that of planet A's. It turns out that for very large gaseous planets (like Jupiter and the "super-Jupiter" class of exoplanets), the surface gravity just increases with the mass of the planet because the size of the planet doesn't change much in this range. The small rocky or icy worlds (e.g., small Solar System bodies, dwarf planets, and worlds like Mercury and Mars) do get bigger as the mass grows, but not enough to offset the increase in mass and thus surface gravity.

Between these two extremes is a rather large transition zone, where the mass and size of a planet grow in such a way that the surface gravity doesn't change much. Earth lies in this zone, as do Venus, Uranus, Neptune, Saturn, and a host of exoplanets that also include some of the worlds currently known as "super-Earths". (Of course, you couldn't actually *walk* on the surface of a gaseous planet like Saturn!) This similarity in surface gravity is surprising, because these worlds are very different in mass, composition, and physical structures. It's not yet clear how to connect "allowable" masses and sizes of planets, but as the database of known worlds increases, the observed properties of these worlds will help place useful constraints on models of how planets form.

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[1] Ballesteros, F. J. and Luque, B. 2016, *Walking on Exoplanets: Is Star Wars Right?*, Astrobiology, Vol. 16, No. 5 (DOI: 10.1089/ast.2016.1475)

In the meantime, exoplanet discoveries indicate that it is not just a coincidence that five worlds in our Solar System have nearly the same surface gravity, even though we don't understand yet why the "transition zone" exists. The article cited in the footnote concludes with, "Therefore, if while viewing *The Force Awakens* the reader sees Harrison Ford walking on Takodana as if he were strolling down Hollywood Boulevard, do not be too critical. After all, this may not be so wrong."

Until next month,

Grace

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