Physics 109: Homework #8 Solutions

8.1 The most accurate way to determine the ages of planetary surfaces is by radioactive dating, which requires actual samples of rocks from the planets. To date this has been possible only for the Earth and its Moon. Remote techniques involve determining the number of impact craters (the crater density). Younger surfaces are those on which flows of molten rock have obliterated earlier craters. Although this only provides a crude estimate of the relative ages of surfaces, it does provide important information on the geological activity of the planet (cf. the northern and southern hemispheres of Mars). Erosive processes will also remove craters as appears to have happened on the Earth.

8.2 Mercury's high density (nearly the same as the Earth's) is a surprise because given its small size it is not expected to have a high internal pressure, so it should not be capable of compressing its material very much. This means that Mercury must contain a higher proportion of denser material (like iron) than the Earth does. It is also a surprise that Mercury has a magnetic field because of its slow rotation rate.

8.3 There are no significant amounts of oxygen gas (O_2) in the atmosphere of Venus, since there is no life cycle on the planet. Any naturally occuring oxygen would be removed very quickly from the atmosphere through chemical reactions with rocks and other atmospheric gases. Although nitrogen gas (N_2) is not the dominant component of Venus' atmosphere it is the second most common gas. It is believed to have come from volcanic outgassing as is the case on the Earth.

8.4 The surface temperature on Venus is 500 K hotter than expected based on balancing the energy input from solar radiation (assuming an albedo of 0) with the energy radiated by the planet. The Earth is only about 30 K hotter. This is a result of the atmospheres on both planets blocking the escape into space of some fraction of the infrared radiation from the surface, which causes the surfaces to heat up. The differences between the greenhouse effect on the Earth and Venus can be traced to the composition of their respective atmospheres. The major greenhouse gases CO_2 and H_2O are merely trace constituents in the Earth's atmosphere, while CO_2 is the dominant component of Venus' atmosphere.

8.5 A large number of craters indicates a primitive surface, since craters are created by the impact of meteorites, a process that is independent of a planet's geological activity. A rifted canyon results when the surface is stretched so that it breaks and pulls apart, which indicates an evolved surface. A corona is a pattern of circular cracks (faults) surrounded by deep trenches, often with associated volcanic flows; an arachnoid is a smooth circular region connected by a web of fractures. Coronae and arachnoids are signs of an evolved surface since they show that some process (not yet well understood) has broken the original crust. Basaltic surface rocks argue for an evolved surface, though not necessarily a very young one. Basalt rocks are created by volcanic activity *after* the initial solidification of the crust. Sedimentary surface rocks are formed by the accumulation of small mineral grains carried by wind, water, or ice to the spot where they are deposited. They indicate an evolved surface where erosive processes have occurred.