OLLI Berkeley Course: The Search for Earth-Like Planets

Warren Wiscombe

Winter 2018

Summary: We live in the most extraordinary age of planet discovery in human history. The number of likely planets around other stars ("exoplanets") has grown from zero in 1990 to over 5000 in 2016. We are beginning to answer age-old questions like: are there other planets like Earth? We are even making fresh discoveries about our own solar system and its "Game of Planets" formation process. This course will survey what we currently know about exoplanets, including: their types; how they form; how we detect them and what we can observe about them; what "habitable" means and which exoplanets are Earth-like and possibly habitable; and what the histories of the Goldilocks Trio (Earth, Mars, and Venus) tell us about possible Earth-like planets elsewhere in our galaxy. At the end, we will speculate about the possibilities of travel to exoplanets and of terraforming them for human use.

Method of instruction: lectures, slides, short video clips, Q&A

Field trip (hopefully): Lick Observatory Automated Planet Finder

Lecture synopsis:

Lecture 1: The exoplanet zoo: hot Jupiters and super-Jupiters, mini-Neptunes, super-Earths, water planets, rogues, and multi-planet systems. Planets around binary stars. The potential climates of these worlds.

Lecture 2: The exoplanet zoo, continued. How exoplanets are detected by space missions and ground-based telescopes. Future missions and telescopes. Exoplanets in science fiction: do we see such planets in the actual exoplanet zoo?

Lecture 3: New discoveries about our own solar system and what they tell us about exoplanets. The methane lakes and rain of Titan. The nitrogen

glaciers of Pluto. New dwarf planets in the Kuiper Belt. Sub-surface oceans on Europa and Enceladus. A possible giant 9th planet.

Lecture 4: Theories of planet formation. Protoplanetary and debris disks. The dynamic evolution of planetary orbits. Leftover "junk" in every solar system. New observations of ongoing planet formation around other stars. How the outer planets of our own solar system migrated as our solar system evolved (The Nice Model).

Lecture 5: Planetary habitability and life on other worlds. What factors make Earth habitable? "Habitable Zones". Greenhouse effect on exoplanets; runaways and snowballs. Comparison of Earth with Mars and Venus, to learn what their radically different climate histories teach us about the ingredients necessary for a habitable planet, and what can turn a planet from a Gaia to a Medea.

Lecture 6: Planetary management: geo-engineering on Earth; terraforming on other planets. Sustainability in the face of the evolutionary mandate "be fruitful and multiply". Overpopulation as an issue for all inhabited planets. Traveling to exoplanets, and how we might get there. Terraforming planets for human use.