ENGINEERING THE SEARCH FOR EARTH-LIKE EXOPLANETS

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Every star in the sky is a sun, and if our sun has planets it seems logical that other stars should have planets also. And they do: in the last two decades, astronomers have found thousands of planets orbiting stars other than the sun, called “exoplanets”. Surprisingly, no solar system copies have yet been found, instead an incredible diversity of exoplanets and planetary systems has been uncovered. Moreover, extrapolating from known discoveries, every star in our Milky Way galaxy should have at least one planet. With hundreds of billions of stars in the Milky Way galaxy and upwards of hundreds of billions of galaxies in our Universe, the chance for one of those planets to be Earth-like should be a near certainty. Yet currently available techniques to find and study small rocky planets have measurement capabilities limited to the planet’s size (or mass) and orbit. In other words similar sized planets such as Venus (with a scorching surface hot enough to melt lead) and Earth (with a clement surface with temperatures supportive of a liquid water ocean and suitable for life) would look the same to current observational capabilities. The ability to observe rocky exoplanet atmospheres and assess the atmospheres for greenhouse gases is required. The detection of biosignature gases: gases produced by life that accumulate in the atmosphere to detectable levels is a prime goal within the search for other Earths.

To find and identify an Earth-like exoplanet, a new generation of space-based telescopes is required, even though these will only have the nearest stars within reach. The telescope must operate above the blurring effects of Earth’s atmosphere. Collecting area is essential; the signal of an Earth orbiting a nearby sun-like star is so dim that less than one visible-light photon would strike the telescope’s primary mirror each second, for a mirror of 10 m in diameter. In the same second, many billions of photons from the host star will flood the telescope, requiring precise separation, suppression and/or shadowing of the star if the Earth-like exoplanet is to be detected and studied. An ultra-precise starlight suppression system is therefore needed. The larger the aperture, the more stars are accessible and the higher the chance of finding a population of exoEarths. The advanced engineering of starlight suppression and deployment or construction of large optical telescopes in space are required for engineering the search for Earth-like exoplanets.

The first speaker, Dr. Amy Lo, will set the stage for large space telescopes by describing the *James Webb Space Telescope* (JWST), an international, NASA-led mission to be launched in 2018. JWST has nearly 4 times the collecting area of the Hubble Space Telescope, and is cryogenically cooled out to mid infrared wavelengths. Dr. Lo works for the JWST prime contractor, Northrup Grumman Corporation and can give the industry perspective for large civilian space missions. The second speaker, Professor Dmitry Savransky from Cornell University will speak to starlight suppression, covering the two main techniques under study: the internal occulter or coronagraph that blocks light inside the telescope and works with wavefront sensing and control to create a stable optical system and the external occulter, or starshade, a specially shaped screen tens of meters in diameter that formation flies tens of thousands of kilometers from its telescope, blocking out the star light so that only planet light enters the telescope. The third speaker, Dr. Jeremy Banik will address construction of large structures in space focusing on large deployables but also including space-based assembly and construction. Dr. Banik leads the Large Deployable Structures Technology Thrust Area at the Air Force Research Laboratory Space Vehicles Directorate at Kirtland AFB. The fourth speaker is Professor Jonathan Black from the University of Virginia. Dr. Black will present the cutting-edge in sensing controls for formation flying and satellite proximity operations primarily focused on enabling autonomy for small satellites, and discuss current challenges and limitations on advances that are required to apply those technologies to space-based planet finding missions.