THE ROLE OF EARTH-BASED OBSERVATORIES FOR SOLAR SYSTEM SCIENCE IN 2050. A. R. Conrad, LBTO, U. of Arizona, Tucson, AZ 85721 (aconrad@lbto.org)

Introduction: In 34 years the current class of 8 to 20 meter ground-based telescopes will be in their twilight, the three extremely large telescopes will seem only modestly large, and several 50+ meter ground-based telescopes (or wider baseline interferometers) will be racing toward first light. The situation in near-Earth space will be similar. JWST will be past its expected lifetime, but one or more 10+ meter class telescopes (or wider baseline interferometers) will be available in near-Earth space or on Earth's moon. Will the majority of these new telescopes be filled-aperture, or will interferometers dominate the landscape?

What will all this mean for planetary science? We explore possible scenarios for each of three cases: Outer solar system, planetary defense, and the Galilean Satellites. For each of these, we consider how the giant telescopes available in 2050 will change: (a) how planetary scientists conduct their research, (b) how Earth-based astronomy will compliment spacecraft missions, and (c) the role of interferometry, versus filled aperture, in Earth-based systems.

Outer Solar System: Today much of what we know of the outer solar system comes to us from observations carried out with telescopes that are Earth-based.1 Space probes (e.g., Voyager and New Horizons) have provided exquisite results on a small population [1] [2], however, for studies that require statistics from a larger population (e.g., a potential 9th planet! [3]) we must rely on Earth-based observations (see Fig. 1). This situation is likely to continue up to, and well beyond, 2050. As we discover more objects in Sedna-like orbits, and with the increasing importance for obtaining astrometry of ever more distant bodies,2 the importance of small population studies enabled by spacecraft that require decades to arrive at the outer solar system will remain low and could possibly decline.

Figure 1. Earth-based observations, like those needed for the discovery and orbit determination of the objects that lead to the 9th planet result (upper panel), versus the exquisite close-up observations given by spacecraft (bottom panel), will continue to compliment one another in the decades to come. But will one of these become the more dominant method for exploring the outer solar system?

Or, in another scenario, the opposite will occur. Interest in deep space exploration will spur research into propulsion systems that send spacecraft outward at a velocity that is higher than what is possible today. This combined with a cubesat style of sending multiple probes in a single package could favor spacecraft for the study of large populations in the outer solar system.

We will estimate the relative cost versus scientific output of these two extremes.

Planetary Defense: For fast-moving NEA, the role of Earth-based observatories will likely continue to be the primary technology to be applied. We will also see improved synergy between optical/infrared observations with active radar Doppler imaging [4]. But for fast moving objects, the giant telescopes of 2050 will only be effective if non-sidereal tracking and guiding is built-in at first light and not retrofit ad hoc. History has shown, for the current class of 8-10 meter telescopes, this is often not the case. [5]

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1 Here, and throughout this discussion, in addition to ground-based telescopes like Gemini, LBT, IRTF, and Keck, we include near-Earth space-based observatories like IRAS, HST, and JWST.

2 In addition to orbits in the ecliptic, we now know that it is important to see bodies at high inclination (e.g., many of the Centaurs) when they are more distant (i.e., not just when they visit the neighborhood of Jupiter).
Galilean Satellites: Unlike the outer solar system, at significant distance for spacecraft visits; or near earth asteroids with a large population, the Galilean Satellites stand as scientific targets that likely favor spacecraft visits over Earth-based observations as the field moves forward in the next decades. In this category, more than the others, the ability of Earth-based telescopes to keep pace with spacecraft probes will be determined by the success of Earth-based interferometry. Today, for example, we have the first planetary science result published for the Large Binocular Telescope (LBT) interferometer, using Fizeau imaging with a 23-meter aperture, to measure emission at Loki Patera (see figure 2).³ [6]

We will further investigate the potential of interferometry to compliment spacecraft visits to the Galilean Satellites.

Figure 2. M-band emission within the lava lake at Loki Patera as measured with the LBT interferometer. [6]

References:

³ It may be possible in future to apply this technique more widely with the next generation interferometer at LBT. [7]