TOWORD CHARCTERIZATION OF EXOPLANETARY SURFACE ENVIRONMENT

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Introduction: Recent astronomical observations have revealed an abundance of planetary systems outside the Solar system. Earth-size exoplanets in so-called habitable zones (HZ) have been already detected. The fraction of M-type stars hosting HZ Earth-size planets is estimated to be order of ten precent ([1][2]). These facts have motivated us for further investigations of these planets in terms of the presence of life as well as compositions of atmosphere and surface. In this context, direct photometry/spectroscopy of HZ planets is situated as an ultimate destination to go because of the potentially rich information it can provide, while it is technically challenging.

Observable features of Point-source Earth: In order to explore our potential to characterize rocky exoplanets with future direct imaging observations, a reasonable starting point is to consider how much we could determine Earth properties when it were observed from afar. To answer this question, disk-integrated spectra of the Earth have been studied at length. It has been shown that the major surface components may be indicated from scattered light of planets based on material-dependent reflectance spectra (e.g. [3]). Molecular absorption features in the spectra were also studied and a handful of biosignature molecules have been put forward e.g. oxygen, ozone, methane, nitrous oxide (e.g.[4]). On the other hand, given our ignorance of the environment there and that many parameters affect disk-integrated planetary spectra, it is not easy to decipher the planetary signal as an inverse problem. However, we may use the time variation of planetary light due to planetary spin rotation and orbital revolution as a probe of global inhomogeneity and localized features. Using the observational and simulation data of multi-photometry of Earth angalogs, we demonstrate the recovery of the major surface features including clouds/ice, continents, and vegetation ([5][6][7]; see also [8][9]). In addition, we discuss the variability of major molecular absorption bands and its applications to cloud coverage and hydrology on exoplanets ([10]).

Beyond Earth: Obviously, the diversity of rocky exoplanet surface environment should be much greater than presently expected. Seeking reasonable samples of various rocky planets, several studies have examined the possible spectra of the Earth during its evolutional development (e.g. [11][12][13]). Complementarily, we review the geologies of Solar system Earth-size bodies and survey their appearances as point sources for a comparative study of various rocky planets.

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