Theoretical investigation on the absorption spectrum of photosystem as a biomarker on extrasolar planets

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Over 900 extrasolar planets have been discovered, and more than 3,000 candidates have been detected. Moreover, planets in habitable zone were observed, and the discovery of Earth-like planets has been expected. Great attentions have been paid to the detection of life in extrasolar planets. For the detection, several indicators have been proposed as biomarkers. One important indicator is red edge [1], which is a characteristic steep gradient observed in the near-infrared region around 750 nm [2]. Actually, red edge is observed in the reflection spectrum of the Earth via the Moon (earthshine [3]). Red edge is affected by many factors, and precise predictions of the red edge are not easy, though the origin of red edge is absorption of plant's chlorophyll [2]. In the Earth, photosynthetic organisms have evolved under the sunlight condition. On the other hand, on extrasolar planets, photosynthetic organisms should evolve differently in many parts, such as pigment types and the arrangements depending on the spectra of the primary star.

Before predictions of biomakers of extrasolar planets, we investigated on the absorption spectrum of chlorophylls in photosystems. Chlorophylls are concentrated in chloroplast, and form pigments-protein complexes in the photochemical systems. Quantum mechanics/molecular mechanics (QM/MM) calculations were performed to calculate the absorption spectrum. Each chlorophyll was included in the QM region. We found that absorption wavelengths are shifted about +10 nm by the effects of protein environment. Similar influence was observed by the effect of amino acid coordination to the central Mg ion in chlorophyll. These results indicate a fine modulation character of adsorption wavelength for photosystem. Current study will be important for understanding photosystems in extrasolar plants as well as diverse photosystems in the Earth.

Reference

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