【Grant-in-Aid for Scientific Research (S)】

A Study for Unveiling Planetary Evolution with Young Transiting Exoplanets

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Purpose and Background of the Research

●Outline of the Research

Exoplanets, which orbit stars beyond our solar system, are now known to number over 5,500. However, the typical age of the known planet host stars is over one billion years (1 Gyr); the number of exoplanets around “young” stars (less than 1 Gyr-old) remains low. During their first billion years, planets undergo significant evolution in mass, radius, orbit, and atmosphere. Observing young planets provides crucial insights with which to improve our understanding of these processes. By establishing a new observational network in the southern hemisphere, we will increase the discovery and characterization of young transiting planets significantly. Observations from this network will provide critical data to test theories of planetary formation and evolution, illuminating the diversity of planets and planetary systems in the Universe (Fig. 1).

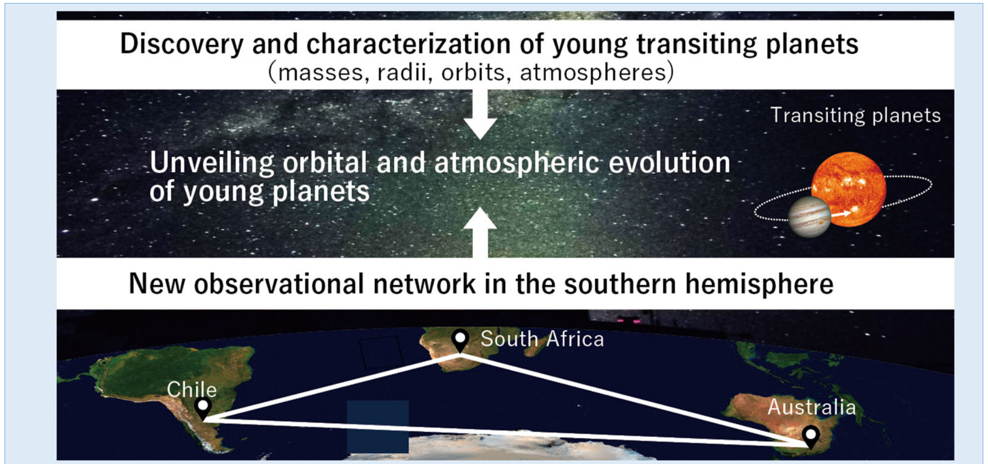

Figure 1. The image of the whole project.

●How to discover new transiting planets

The method for discovering new transiting planets involves observing dimming of the host star during the planet’s transit. NASA’s TESS mission is currently finding transiting planet candidates, including around known young stars. Many of them are genuine planets, while others are false positives involving eclipsing binaries. Follow-up observations can distinguish these two scenarios and validate real planets, by observing transits at multiple wavelengths (Fig. 2). Eclipsing binaries exhibit dimming that varies with wavelength, while planets do not, because they do not emit light.

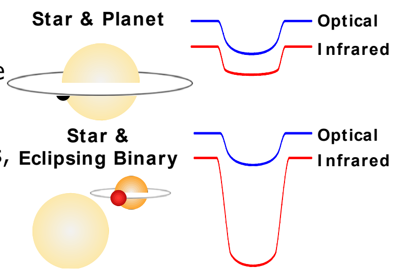

Figure 2. A conceptual diagram for validating new transiting planets.

●The challenge and benefits of discovering young transiting planets

Young stars have starspots and rotate rapidly, causing wavelength-dependent variability. Observing transits at different wavelengths can thus not only help discover young planets, but also measure their sizes more accurately. Because young star clusters are mostly observable from the southern hemisphere, our novel two-channel camera network will lead to breakthroughs in discovering young transiting planets. Furthermore, these instruments can precisely measure variations in the timing of planetary transits, which provides a powerful way to constrain their masses, densities, and compositions.

●The orbital distribution of known transiting planets

The periods and radii of known transiting planets show features such as the hot Jupiter population, the Neptunian desert, and the radius gap, seen for planets with ages over 1 Gyr (Fig. 3). For young planets, these characteristic distributions are still unclear.

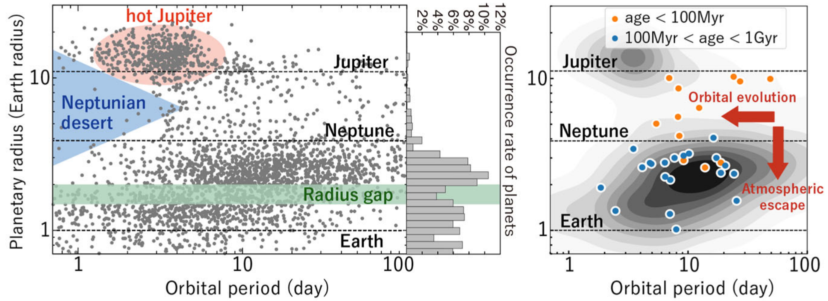

Figure 3. The periods and radii for known transiting planets: The left side represents the distribution for planets aged over 1 Gyr, while the right side compares planets less than 1 Gyr with the older population contour. Young planets are believed to evolve significantly within their first 1 Gyr. This evolution involves orbital migration toward the inner regions and atmospheric escape leading to reduced radius and mass.

Expected Research Achievements

●How do young planets and planetary systems evolve?

In this study, we create a new southern hemisphere observing network, which will boost the rate of young transiting planet discoveries. Investigations of these planets will reveal how the orbital period and radius distributions evolve with time. Follow-up observations using our network, the Subaru telescope, and other telescopes will enable characterization of the masses, radii, orbits, and atmospheres of these young planets. These observational results will be used to test and inform planetary formation and evolution theories. This research will thus ultimately contribute to and advance our knowledge of the origins and diversity of planetary systems (Fig. 4).

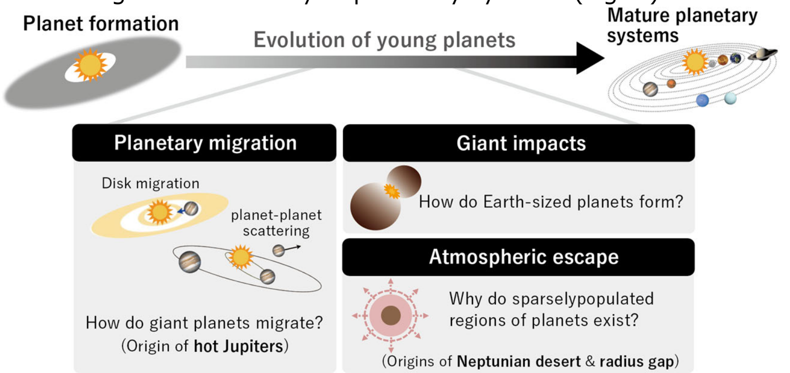

Figure 4. A conceptual diagram of what we are aiming to reveal in this study.

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