A Spectroscopically Confirmed Double Source Plane Lens System in the Hyper Suprime-Cam Subaru Strategic Program

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Strong gravitational lensing of distant objects provides us with powerful constrains on the matter distribution of the lens galaxy. The vast majority of the known strong lensing systems have a single background source, but in very rare cases, two background sources can be simultaneously lensed by the same foreground galaxy. Such double source-plane lens systems are extremely rare, but they are a very valuable probe of cosmology as they are sensitive to the cosmic expansion.

Currently, there are only a few known double source-plane lens systems. We have discovered another one in Hyper Suprime-Cam Subaru Strategic Program (HSC-SSP) as reported in Tanaka et al. [1]. Fig. 1 shows the system. The lens galaxy at the center is a very massive galaxy at $z = 0.79$ likely at the center of a cluster. On the bottom-right of the lens, there is a red arc (S1) with a counter image just on the left of the lens galaxy (H). The second source is the blue Einstein ring (S2) with several knots (A-G). The system is dubbed 'Eye of Horus' due to its resemblance to the symbol of ancient Egyptian god.

We have made a follow-up spectroscopic observation of the background sources with FIRE on Magellan. We confirm that the red inner arc is a galaxy at $z = 1.3$ and the blue ring at $z = 2.0$ using several emission lines from the galaxies. In all of the previously known systems, the second galaxy is too faint to confirm spectroscopically. Our system is the first double source-plane lens system with spectroscopic redshifts of both sources. This is important because the spectroscopic redshifts are essential to derive cosmological constraints from the system.

We have modeled the system with two independent methods. Both models successfully reproduce the overall configuration of the system. However, any smooth models do not reproduce the A+C split, implying the existence of a subhalo or foreground structure. We do not observe a clear hint of a satellite galaxy in the HSC images, but we have been awarded further follow-up observations with ALMA and LGSAO-assisted near-IR imaging observations. These observations may be able to detect the satellite galaxy responsible for the split, allowing us to model the system more precisely.

We expect to find 10 more such double source-plane lens systems in HSC-SSP. Combining all of them together, we expect to place a very strong, highly complementary constraints to other probes on the cosmological parameters.

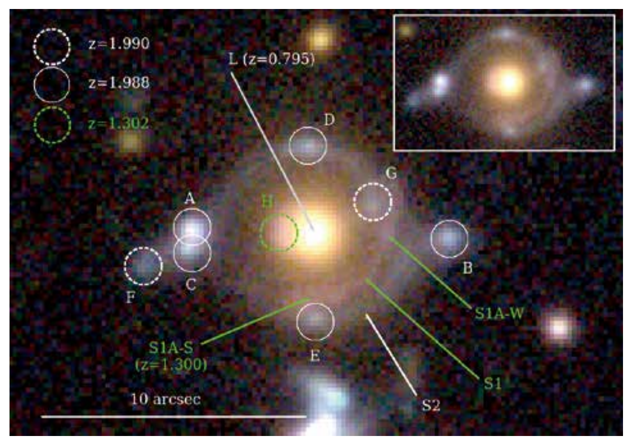

Figure 1: Pseudo-color image of the lens system. The prominent knots in inner arc (green) and outer ring (white) are labeled and the measured spectroscopic redshifts are indicated. The inset shows the image without symbols. The horizontal bar shows a scale of 10 arcsec.

Reference

[1] Tanaka, M., et al.: 2016, *ApJL*, **826**, L19.