The Widest-Separation Substellar Companion Candidate to a Binary T Tauri Star

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Direct imaging surveys are powerful tools to search for Jupiter-mass planets around young stars, and those searchers are useful to study the theory of the formation of giant planets with wide orbits around their parent stars. Recent direct imaging surveys show that the projected separation of young planetary-mass companions (PMCs) are surprisingly wide compared with the orbital separations of planets in our solar system, extra-solar planets detected by indirect methods, and predictions of the standard core accretion model [1]. These results may suggest a diversity in the formation and evolution of PMCs. (e.g., [2]).

We present the results of the direct imaging of a PMC candidate around a *binary* T Tauri star, SR12AB (K4–M2.5), in the ρ Oph star-forming region [3]. The rst discovery of the PMC candidate, SR12 C, was made through the imaging observations carried out on 2002 using the near-infrared camera SIRIUS mounted on the 1.4-m telescope IRSF. SR12C is separated by ~8.7″, corresponding to 045 1100 AU at 125 pc (Fig. 1).

The associated members of a star-forming region share a common proper motion, and thus can be distinguished from background objects by investigating their proper motions from images obtained at multiple epochs. Two epoch images using Subaru (IRCS and CIAO), and three archive date sets (HST/NICMOS, VLT/NACO, and Gemini/QUIRC+Hokupa'a) are used for precise astrometry of the SR12 system. The separation of SR12C from SR12AB is constant from 1998 to 2008, suggesting physical relation of them. In addition, the H band spectra of SR12C shows a triangular shape, which is a characteristic feature of *young*, late-ytpe dwarfs with low surface gravity. Therefore we conclude that SR12C is a member of the ρ Oph star-forming region. In addition, the probability of a chance alignment of objects in ρ Oph, physically associated with SR12AB is very low (~1 %), indicating that SR12C is a genuine companion to SR12 AB.

Using an age-luminosity diagram, we estimate the mass of SR12 C. It has an J-band absolute brightness of 10.5 mag and infrared spectra suggesting a spectral type of M9.0 ± 0.5 and $T_{\rm eff} \approx 2400$. The bolometric luminosity of SR12C was estimated to be $\log(L/L_{\odot}) = -2.87 \pm 0.20$. Assuming that the age of SR12C is the same as those of YSOs in ρ Oph, the mass of SR12C was estimated as $0.013 \pm 0.007\,M_{\odot}$ ($14^{+7}_{-8}\,M_{\rm Jup}$) by comparing with models. Therefore SR12C is a strong PMC candidates, and the rst PMC candidate directly imaged around a *binary* T Tauri star. Considering the projected separation from SR12 AB, SR12C has the widest separation from its parent star among PMC candidates imaged so far[1]. This discovery spreads the range of distributions of the PMC candidates from ~50 to 1100 AU.

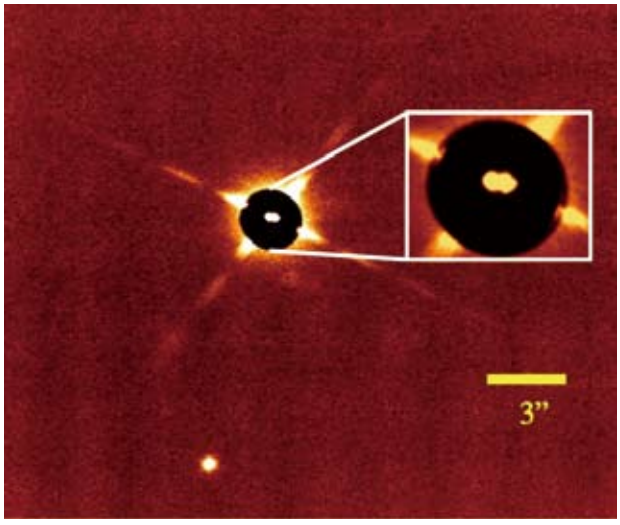

Figure 1: Subaru/CIAO K-band coronagraphic image of a binary T Tauri star SR12 AB and its planetary-mass companion candidate SR12 C. The parent binary star is blocked by the occulting mask. The companion (SR12 C) is separated by ~8.7″, corresponding to ~1100 AU at 125 pc.

* When the manuscript was submitted, PMO candidates with the similar separations with SR12 C were reported (e.g., [4]).

References

[1] Pollack, J. B., et al.: 1996, *Icarus*, **124**, 62.
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[3] Kuzuhara, M., et al.: 2011, *AJ*, **141**, 119.
[4] Burgasser, A., et al.: 2010, *ApJ*, **725**, 1405.