A Survey of Nearby M-dwarfs with Robo-AO

Amy Ray, Angelle Tanner, Reed Riddle

Overview

Low mass stars have been difficult to observe until recently, therefore less is known about distributions in their populations, such as how many are in bound systems. This information is crucial for star formation models because observations are used to make sense of model outputs. In this study, the number of bound systems for a sample of 178 M-dwarfs close to our solar system were determined to reduce this deficit for low mass stars. Images were collected, using the Robotic Adaptive Optics (Robo-AO) camera on the Palomar 60 inch telescope, over two years. A total of 50 bound systems were found. Compared to surveys of different stellar types, out results fit the trend of the number of bound systems decreasing with decreasing stellar mass. These results will improve the accuracy of star formations models which will enhance our understanding of stellar evolution.

What are M-dwarfs?

M-dwarfs are small, cool stars that compose the majority of stars in the Milky Way. Figure 1 gives a comparison of an M-dwarf and the Sun. The best quality of information on these stars is obtained by observing the ones that are relatively close to our solar system. We can only reliably observe the ones that are nearby due to these stars being so small and therefore less luminous. Previous studies on M-dwarfs suggest that a large portion of them form multiple star systems (Ward-Duong 2015) which is what this survey sought to test.

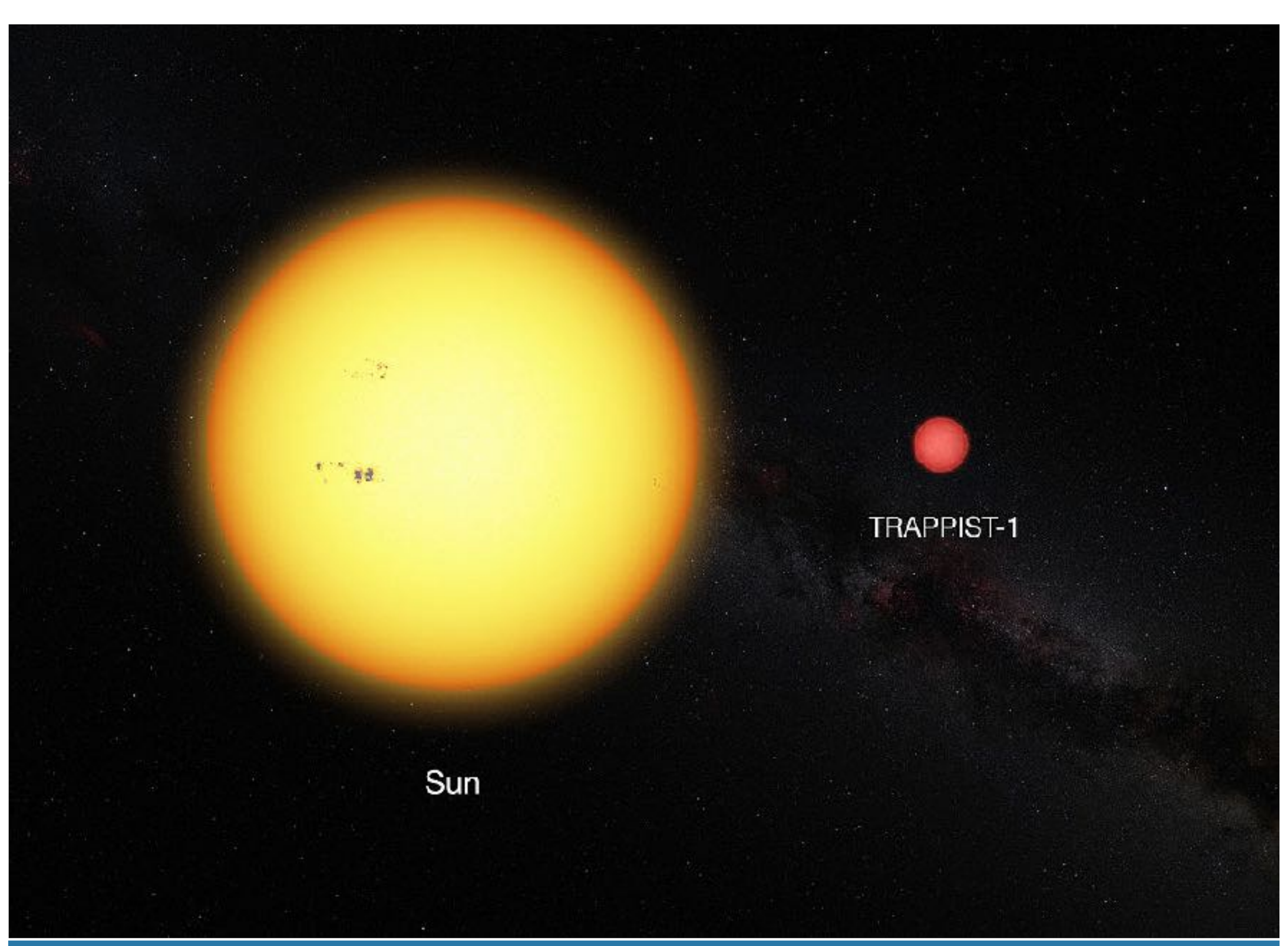

Figure 1. Size comparison of an M-dwarf star and our Sun. The M-dwarf shown here, called TRAPPIST-1, has 8% the mass of the Sun and was also recently discovered to host 7 extrasolar planets.

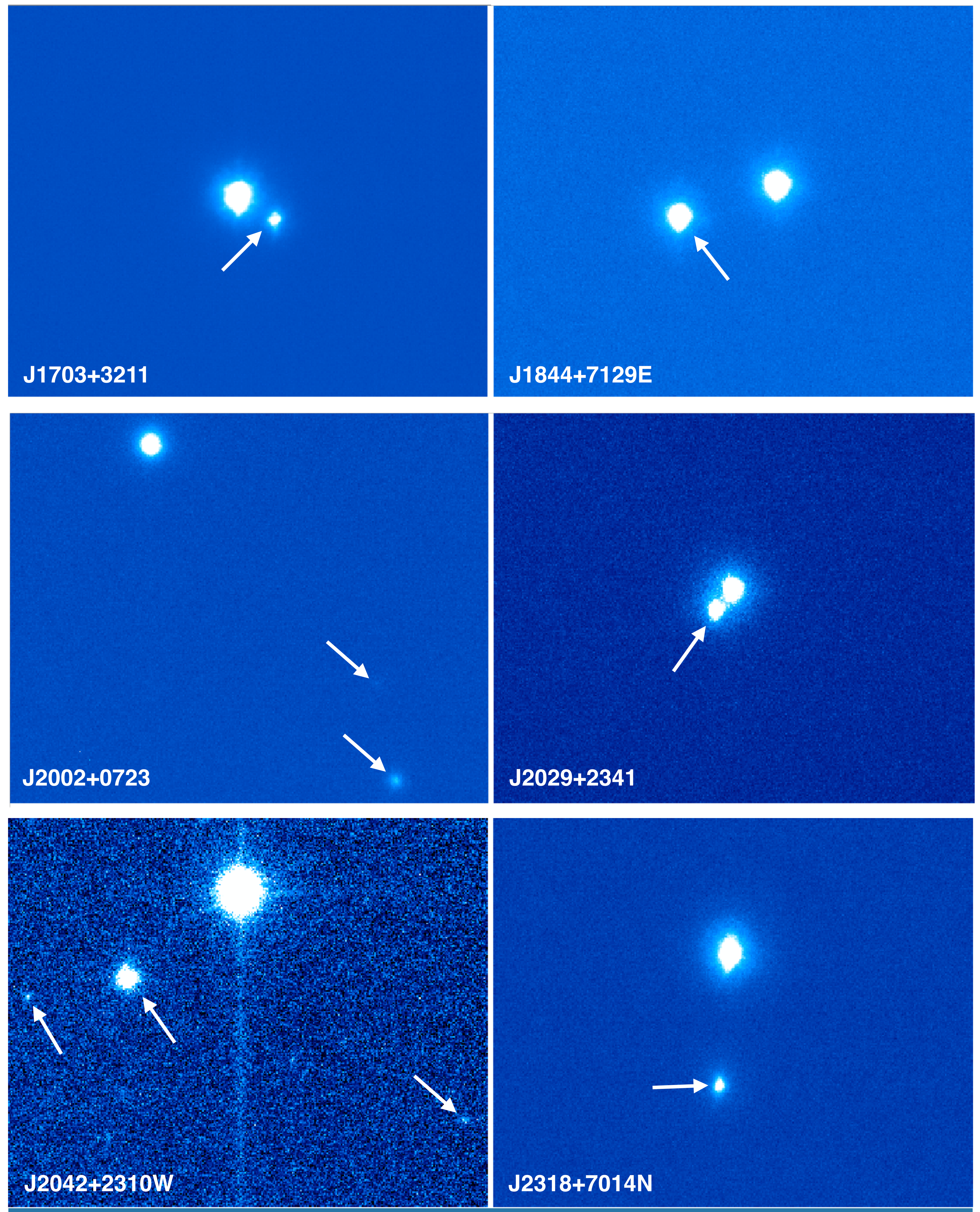

Figure 3. Examples of confirmed multiple star systems. The white arrows indicate companions to the primary star in each image. Images with one arrow indicate binary systems, two indicate a triple system, and three indicate a quadruple system.

Observations

Data for the 178 M-dwarf sample was taken using Robo-AO. An adaptive optics system works by correcting for distortions caused by the Earth's atmosphere using reflected laser light. Figure 2 shows the laser from Robo-AO. With the Robo-AO system, we were able to detect companion stars that would not have been visible with a non-adaptive optics system. An example of AO revealing a companion star is shown at the top of Figure 2. Two sets of images were taken for each target, one in 2012 and another in 2014. This allowed us to observe changes in positions of the stars over time. Stars that did not change position with respect to each other were in bound systems called common proper motion systems.

Determining Candidates

All of the images were inspected by eye and those which showed companion candidates within the FOV were re-observed to determine whether they exhibited common proper motions. Using the additional epoch of images collected two years later, those stars with a less than 3 sigma change in their separation and position angle are identified as common proper motion binaries. Figure 2 shows examples of some of the systems that were found. The flux and masses were determined for each star in the bound systems using aperture photometry in IDL and the luminosity mass relation.

Results and Future Work

- A total of 50 multiple systems of M-dwarfs were found
- The fraction of multiple star candidates determined in this survey was similar to other surveys conducted for the same stellar type
- With a third set of observations from the Robo-AO camera now located at Kitt Peak on the 2.1 m telescope, the orbits of these systems can be constrained
- Close to 250 targets are going to be observed at Kitt Peak which will increase the original sample size
- The fraction of bound systems to single stars can also be used to examine results from models of M-dwarf star formation

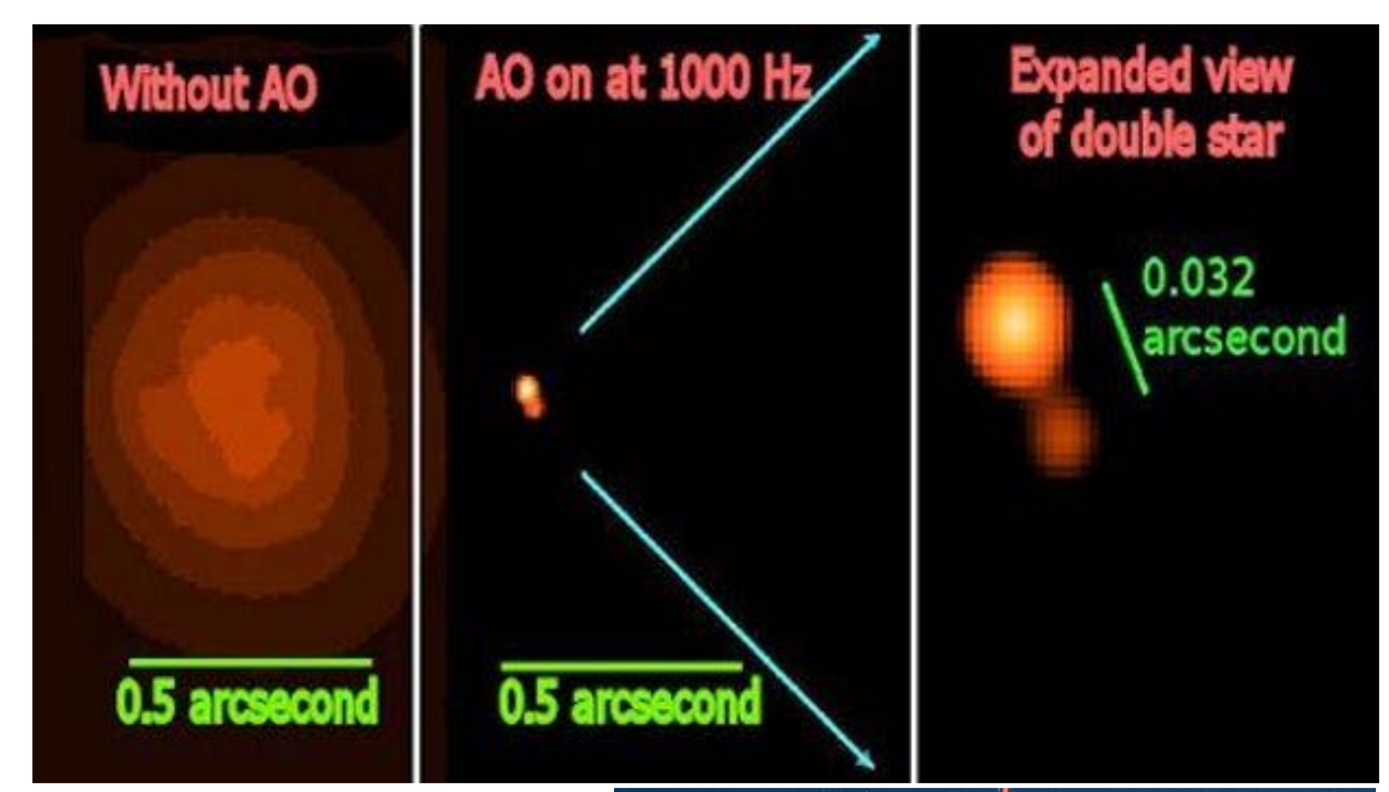

Figure 2. (Above) An example of an adaptive optics system revealing two stars. (Right) The Palomar 60 inch telescope shown with the laser of the Robo-AO system firing.