Brown Dwarfs
IAU Symposium, Vol. 211, 2003
E. L. Martín, ed.

Surveying the Solar Neighborhood for Brown Dwarf Companions with the ECLIPSE Discovery Mission

Karl Stapelfeldt

Jet Propulsion Laboratory, California Institute of Technology, Mail Stop 183-900, 4800 Oak Grove Drive, Pasadena CA 91109 USA

Abstract. The proposed *Eclipse* Discovery mission is an optical space telescope designed to provide a thousandfold reduction in scattered light near bright stars in comparison to any Hubble Space Telescope instrument. A survey of 500 single stars within 15 pc can detect companions with absolute z magnitude of 22 at separations > 10 AU in most of the targets. Spectrophotometry of CH_4 and H_2O bands between 0.8-1.0 μm can be used to derive the effective temperatures of the objects. The ECLIPSE brown dwarf survey would directly measure the luminosity function of brown dwarf companions down to ~20 Jupiter masses, providing a crucial comparison with field objects.

Brown dwarf companions may form in one of two ways: through accretion in a circumstellar disk, or through the collapse of separate bound cloud cores, the same process which produces stellar companions. At separations beyond a few hundred AU (the typical outer radius of a young protoplanetary disk), the disk formation mechanism is unlikely to operate efficiently. Direct imaging surveys (Gizis et al. 2001) find that at wide orbital separations, brown dwarf companions appear to be as common as stellar companions. However, radial velocity surveys have noted the absence of brown dwarf companions to FGK stars at semi-major axes less then a few AU. The brown dwarf companion population at intermediate separations (5-50 AU) has yet to be measured. At these orbital radii, radial velocity and astrometric surveys would require decades to detect companions indirectly. Direct imaging systems offer the prospect of rapid detection, but have had relatively little success due to the limitations of current generation high contrast imaging systems (Oppenheimer et al. 2001). Because the lower mass brown dwarfs are thought to be the most numerous, and these objects cool the most rapidly, a large population of heretofore undetected brown dwarf companions could be present in the solar neighborhood (Reid et al. 1999).

Eclipse is a proposed NASA Discovery mission, an optical coronagraphic space telescope for exoplanetary astronomy. It is designed to meet the requirements of high contrast imaging and spectrophotometry, reducing the diffracted and scattered starlight at one arcsecond angular separation from bright stars by three orders of magnitude compared to any Hubble Space Telescope instrument. *Eclipse* brings together a telescope with aperture of 1.8 meters, configured for low optical scattering; a coronagraphic camera for control of diffracted light; and a precision deformable mirror to control light scattered by imperfections in the telescope optics. The *Eclipse* mission will return unique science on the nature of planetary systems associated with our Sun's nearest neighbors, and on the processes governing their formation and evolution. During a three-year survey of stars in the solar neighborhood, *Eclipse* will directly detect and characterize jovian-mass planets orbiting AFGK stars to 20 pc; image the structures within protoplanetary and debris disks; and provide a powerful capability to detect and study brown dwarf companions in the solar neighborhood. A survey of 500 single stars within 15 pc can detect companions with absolute z magnitude of 22 at separations > 10 AU in most of the targets. Spectrophotometry of CH_4 and H_2O bands between 0.8-1.0 μm can be used to derive the effective temperatures of the objects. The *Eclipse* brown dwarf survey would directly measure the luminosity function of brown dwarf companions down to ~20 Jupiter masses, providing a crucial comparison with field objects.

Eclipse will study brown dwarfs companions through their thermal emission at wavelengths from 0.7-1.1 μm. Thanks to recent theoretical advances, brown dwarfs can now be readily characterized from optical measurements (Burrows et al. 2002). Strong Na and K resonance lines, the broad CH_4 bands, plus an H_2O band at 0.93 μm, can be used to diagnose the brown dwarf spectral class and surface gravity. *Eclipse* will observe brown dwarfs though spectrophotometry and grism spectroscopy at R=100.

To simulate the population of brown dwarf companions within reach of the *Eclipse* instrument design, exposure time calculations were performed for detection of objects with T_{eff} = 600 K in the Johnson I and Gunn z bands. Model *Eclipse* point spread functions, featuring a square "dark hole" where scattered light has been cleared by the telescope's active optics, were used along with predicted thermal fluxes supplied by *Eclipse* science team member A. Burrows. A companion was planted at a specified separation from each star in the Hipparcos catalog. Exposure times are for S/N= 10.

Imaging band	Companion separation (AU)	Number of systems with BD detected in < 1 hour	Max distance of system (pc)
I	5	176	10
I	10	312	15
I	20	383	15
z	5	350	14
z	10	2000	28
z	20	4300	40

As shown in the Table, *Eclipse* will offer a powerful capability to detect brown dwarf companions in thousands of stellar systems within 40 pc of the Sun.

References

Burrows, A. et al. 2002 Ap.J. 573 394

Gizis, J.E., Kirkpatrick, J.D., and Wilson, J.C. 2001 A.J. 121 2185

Oppenheimer, B.R. et al. 2001 A.J. 121 2189

Reid, I.N. et al. 1999 Ap.J. 521 613

https://doi.org/10.1017/S0074180900211273 Published online by Cambridge University Press