Exploring the Formation and Evolution of Planetary Systems
Proceedings IAU Symposium No. 299, 2013
M. Booth, B. C. Matthews & J. R. Graham, eds.

doi:10.1017/S1743921313007874

The Gemini NICI Planet-Finding Campaign: The Frequency of Giant Planets around Young B and A Stars

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Abstract. We have carried out high contrast imaging of 70 young, nearby B and A stars to search for brown dwarf and planetary companions as part of the Gemini NICI Planet-Finding Campaign. Our survey represents the largest, deepest survey for planets around high-mass stars (≈1.5–2.5 $M_\odot$) conducted to date and includes the planet hosts β Pic and Fomalhaut. Despite detecting two new brown dwarfs, our observations did not detect new planets around our target stars, and we present upper limits on the fraction of high-mass stars that can host giant planets that are consistent with our null result.

Keywords. stars: brown dwarfs, instrumentation: adaptive optics, planetary systems, stars: individual (HIP 79797)

The Gemini NICI Planet-Finding Campaign is a 4-year direct imaging survey designed to determine the frequency of giant planets at large and medium separations, and to determine how that frequency depends on stellar mass (Liu *et al.* 2010). As part of the Campaign, we surveyed 70 young B and A stars, and detected a 33^{+12}_{-9} M_{Jup} (M_H = 9.57 ± 0.13 mags) brown dwarf around the star HD 1160 (Nielsen *et al.* 2012), confirmed the known brown dwarf around HR 7329 (Lowrance *et al.* 2000), and found that the previously-known brown dwarf HIP 79797 B (Huélamo *et al.* 2010) is itself a tight (3 AU) brown dwarf binary, with masses 58^{+21}_{-20} and 55^{+20}_{-19} M_{Jup} (H = 10.16 ± 0.16 and 10.28 ± 0.16 mags). Follow-up of all other new candidate companions within 400 AU projected separation for stars not in crowded fields found all these candidates to be background objects. We also demonstrate a new Bayesian technique to determine ages for field B and A stars that more accurately determines ages and uncertainties from color-magnitude diagram position. We find that the typical method for determining the ages of field A stars by comparison to the Pleiades color-magnitude diagram systematically underestimates the ages of these stars, by up to several hundred Myrs. Our results are described in depth in Nielsen *et al.* (2013).

As we do not detect planets around our 70 high-mass stars we are able to place strong upper limits on the fraction of such stars that can host a wide-separation planet, following the Monte Carlo technique used previously in Nielsen *et al.* (2006), Nielsen *et al.* (2008), and Nielsen & Close (2010). Figure 1 shows the 95% confidence upper limits we can place on giant planets orbiting 2 $M_\odot$ stars as a function of planet mass and orbital semi-major

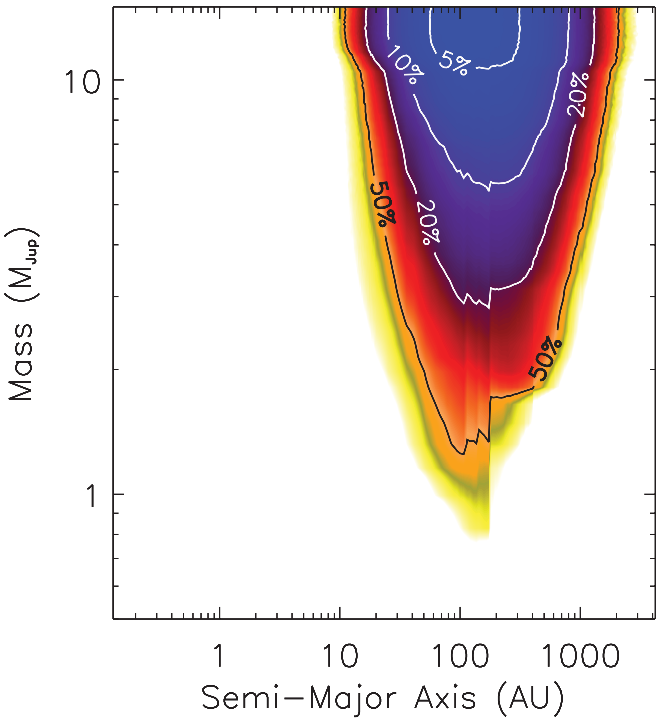

Figure 1. Upper limit on the fraction of 2 $M_\odot$ stars that can have planets as a function of mass and orbital semi-major axis given the null result of the NICI Campaign for planets, at 95% confidence. We use the evolutionary models of Baraffe *et al.* (2003) to convert between NIR magnitude and mass as a function of age.

axis. We find that giant planets around such stars are not common, with fewer than 20% of these stars having 4 M_{Jup} planets between 59 and 460 AU. Planets like HR 8799 b (7 M_{Jup}, 68 AU) appear to be rare around high-mass stars: fewer than 10% of B and A stars can have such a planet at 95% confidence. Given the limited number of nearby, young B and A stars improved statistics will likely not come from larger sample sizes but rather from improved instrumentation, as extreme planet-finding instruments like GPI and SPHERE search for planets around these (or similar) high-mass stars at much smaller projected separations between star and planet.

References

Baraffe, I., Chabrier, G., Barman, T. S., Allard, F., & Hauschildt, P. H. 2003, A&A, 402, 701
Huélamo, N., Nürnberger, D. E. A., Ivanov, V. D., *et al.* 2010, A&A, 521, L54
Liu, M. C., Wahhaj, Z., Biller, B. A., *et al.* 2010, Proceedings of SPIE, 7736
Lowrance, P. J., Schneider, G., Kirkpatrick, J. D., *et al.* 2000, ApJ, 541, 390
Nielsen, E. L., Close, L. M., & Biller, B. A. 2006, IAU Colloq. 200: Direct Imaging of Exoplanets: Science & Techniques, 111
Nielsen, E. L., Close, L. M., Biller, B. A., Masciadri, E., & Lenzen, R. 2008, ApJ, 674, 466
Nielsen, E. L. & Close, L. M. 2010, ApJ, 717, 878
Nielsen, E. L., Liu, M. C., Wahhaj, Z., *et al.* 2012, ApJ, 750, 53
Nielsen, E. L., Liu, M. C., Wahhaj, Z., *et al.* 2013, 776, 4