Giant Planet Occurrence Rate as a Function of Stellar Mass

Sabine Reffert[1], Christoph Bergmann[1,2], Andreas Quirrenbach[1], Trifon Trifonov[1], Andreas Künstler[1,3]

[1] Landessternwarte, Heidelberg [2] Univ. Canterbury, New Zealand [3] AIP Potsdam, Germany

Introduction

- we have monitored precise radial velocities of a sample of 373 G and K giants at Lick Observatory for between 6 and 12 years
- stellar masses in this sample range from about 1 $M_\odot$ to more than 5 $M_\odot$
- we have identified 17 planets and 26 planet candidates in altogether 35 systems; see their mass distribution in Fig.1
- we are sensitive to giant planets only (masses larger than about 1-2 M_{Jup}); typical periods are 0.5 to 2.3 years

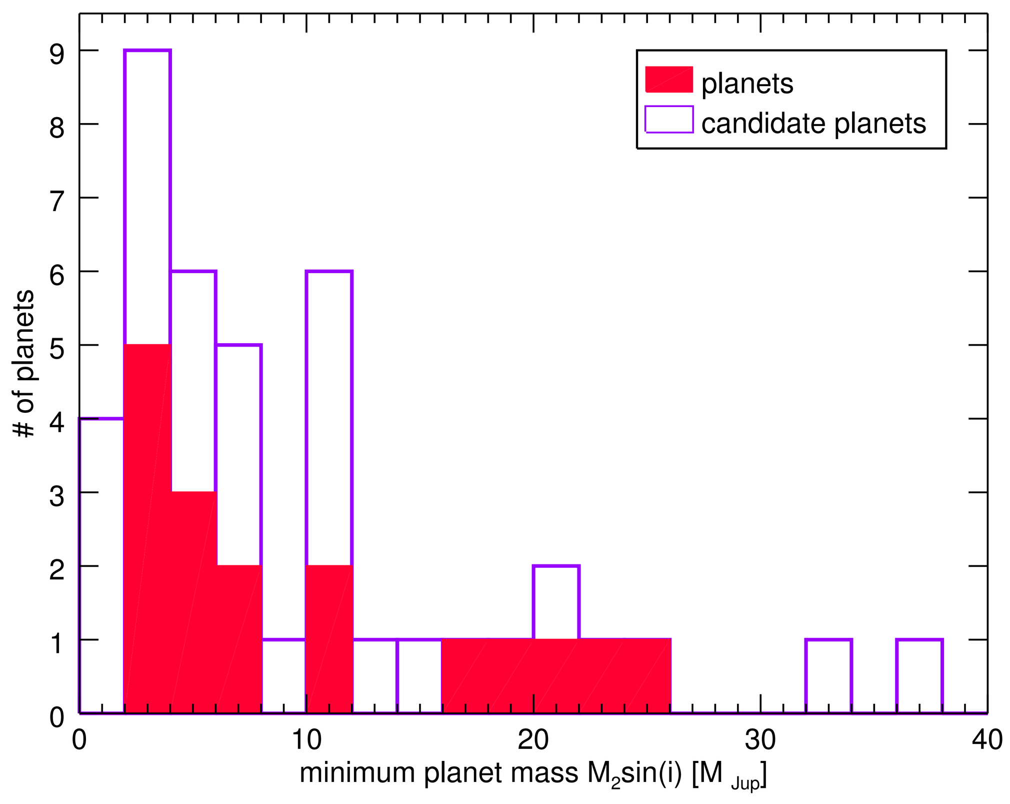

Fig.1: Mass distribution of 17 planets and 26 planet candidates (24 shown; 2 outside plot limits) identified in our sample. The smallest mass of a confirmed planet is 2.3 M_{Jup} (for simplicity, we refer to all substellar companions as planets here).

Conclusions

- the giant planet occurrence rate is a strong function of stellar mass
- the giant planet occurrence rate peaks at stellar masses of about 1.9 $M_\odot$, and decreases quickly for larger masses
- we do not find a single confirmed planet in the stellar mass range from 2.7 to 5 $M_\odot$, although there are 113 such stars in our sample; this corresponds to an upper limit for the giant planet occurrence rate of 1.6% in that mass range (68.3% confidence)
- results consistent with semi-analytic formation models by Ida & Lin (2005) and Kennedy & Kenyon (2008)
- giant planet formation seems to be suppressed around higher mass stars, probably because the snow line is located further out, which leads to reduced growth rates, faster disk depletion and longer migration timescales

References

Fischer, D.A., Valenti, J., 2005, ApJ 622, 1102
Ida, S, Lin, D.N.C., 2005, ApJ 626, 1045
Johnson, J.A., Aller, K.M., Howard, A.W., Crepp, J.R., 2010, PASP 122, 905
Kennedy, G.M., Kenyon, S.J., 2008, ApJ 673, 502

Results

- we show the giant planet occurrence rate as a function of mass and metallicity in Figs. 2 and 3 below
- the confirmed planets follow the same planet-metallicity distribution as known for main-sequence stars (Fischer & Valenti 2005)
- we confirm the trend found by Johnson et al. (2010) for subgiants that the planet occurrence rate rises for stellar masses up to 2 $M_\odot$ (the maximum mass in their sample)
- for even higher masses, however, we find a strong decrease in the giant planet occurrence rate
- we do not find any confirmed planet in our sample for a star more massive than 2.7 $M_\odot$, although there are 113 such stars in our sample
- we have shown that this is not a bias due to reduced planet detection capability for higher mass stars (Reffert et al., in prep.)

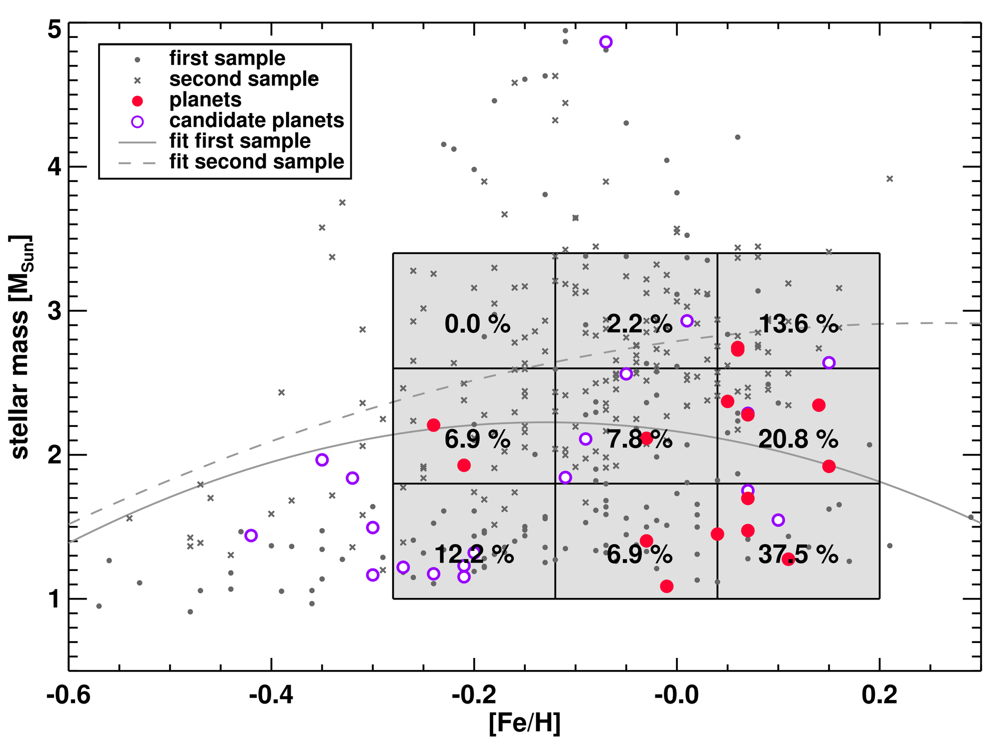

Fig.2: Fraction of stars (percentages) with planets and/or planet candidates for various bins in metallicity and stellar mass. Clearly, the giant planet occurrence rate in our Lick sample increases strongly with stellar metallicity and decreases with stellar mass.

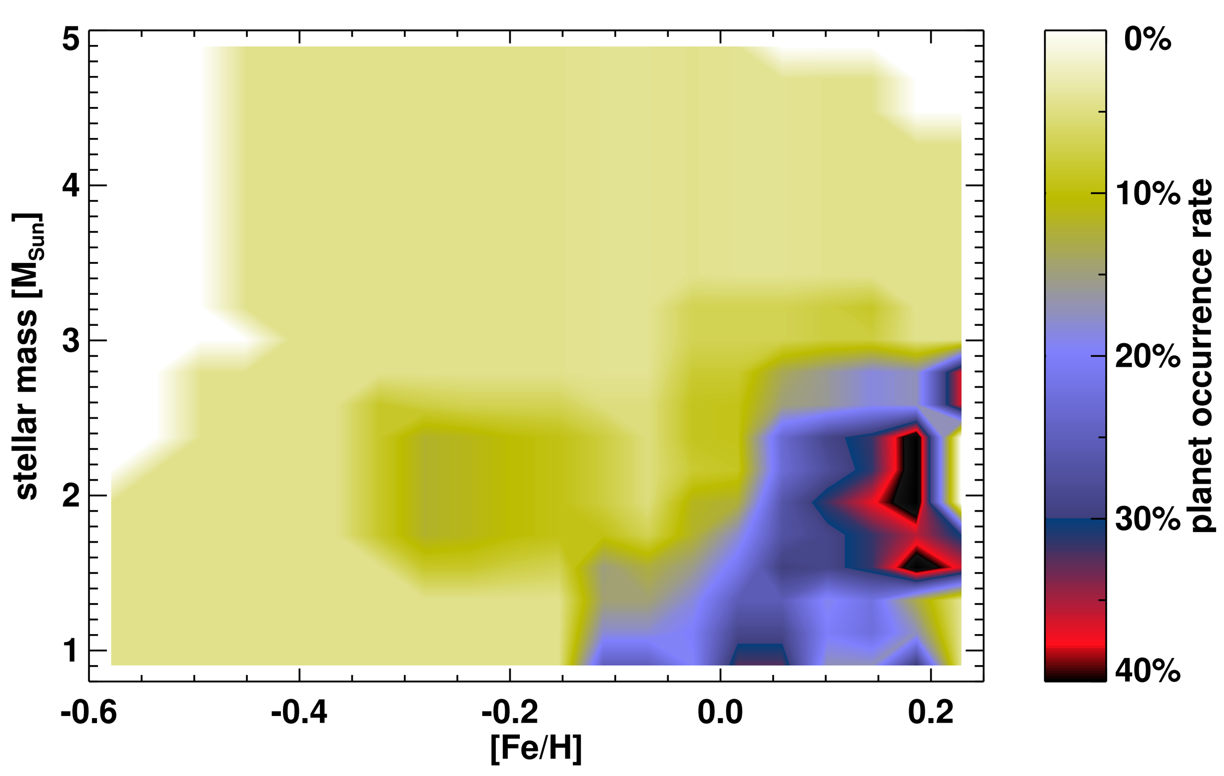

Fig.3: The same data as shown in Fig.2, using only confirmed planets and heavily smoothed. Averaging over stellar mass reveals the same planet-metallicity correlation as is known for main-sequence stars. Averaging over metallicity reveals a sharp decrease in giant planet occurrence rate for masses lager than about 2.5 $M_\odot$.

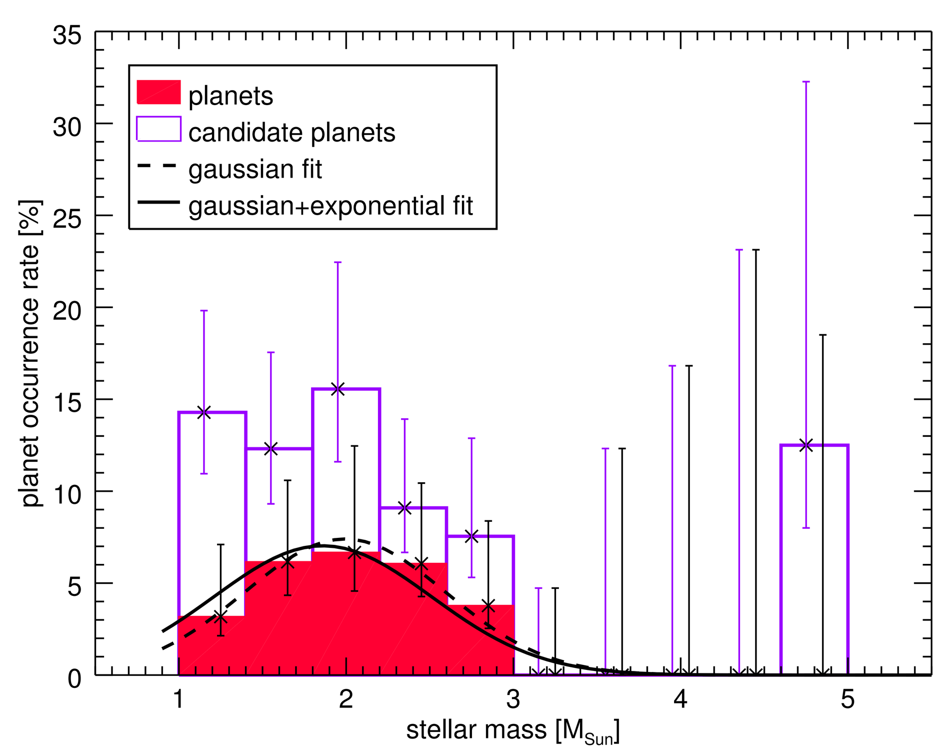

Fig.4: Giant planet occurrence rate as a function of stellar mass. There is a clear peak in the occurrence rate at masses around 2 $M_\odot$. For masses larger than 2.5-3 $M_\odot$, the giant planet occurrence rate quickly decreases.