VLTI/Hi-5: detection yield predictions for young giant exoplanets

Conference or Workshop Item

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INTRODUCTION

The scarcity of giant exoplanets discovered by ongoing single-aperture direct imaging surveys currently challenges our understanding and theories of planet formation. For the nearest population of young stars, surveys are typically sensitive to planets further away than 10 AU from their host stars due to the instrument’s limited angular resolution. It gives access to the semi-major axes where giant planets could have formed in situ. However, it hardly fills the gap with the exoplanet population discovered by radial velocity surveys. Filling this gap is essential because it can provide critical constraints on planet formation theories and evolution models.

We present our simulations of potential detections around young extra-solar planetary systems and a potential target list for the Hi-5 instrument.

Hi-5 is a high-contrast L’ band (3.8 μm) nulling interferometric instrument. It is currently being proposed to ESO as a visitor instrument for the Very Large Telescope Interferometer (VLTI) and became the first long-baseline nuller in the Southern hemisphere.

METHODS

At young ages, the planet formation process can be constrained by measuring the flux of the planet\(^1\).

We identified 4002 stars (Figure 1) as members of young stellar associations within 150 pc of the Sun thanks to the BANYAN algorithm and other searches for young moving group members\(^2\).

![Fig. 1: Age, L’ band magnitude, mass, distance, spectral-type, and snowline position distribution for our stellar catalog.](image)

Around each of these stars, planets are simulated according to two formation models, the Generation III Bern model (cold-start mode) and the AMES-Dusty model (hot-start model) combined with a Monte Carlo planet generator\(^3,4\).

Our end-to-end simulator, SCIFYsim, provides sensitivity maps (Figure 2)\(^5\). They are pre-computed for the Auxiliary Telescopes (ATs) of the VLTI with a spectral resolution of R = 20\(^6\).

Each planet is placed on these maps (magnitude) and the detection yield is recovered for both formation models.

RESULTS

Cold-start model

The occurrence of sub-giant and giant planets with the Bern model is low and depends on the stellar mass\(^7\). The probability of generating these planets is below a few percent.

Our simulations show that no planet can be detected with Hi-5. The L’ band magnitude histogram (Figure 3) indicates that massive planets (M > 0.75 M\(_{\text{jup}}\)) have a too high magnitude (sensitivity around 12-13 for the ATs).

![Fig. 2: Sensitivity map computed by SCIFYsim for a 4.9 mag star with the ATs (R = 20) and the large configuration. Both red dots correspond to randomized planets.](image)

Hot-start model

Contrary to the Bern model, planets with the hot-start model are generated from statistics (Kepler and radial velocity surveys) and more precisely with the Fernandes power-law distribution\(^8\).

It exists a turnover in the distribution near the snow line region.

Hot-start planets are brighter and therefore detectable (Figure 4). The model generates more giant planets, especially around low-mass stars. It explains the cumulative number of detections.

![Fig. 4: L’ band magnitude for hot-start giant planets (whole stellar catalog).](image)

![Fig. 5: Cumulative number of detections for different VLTI configurations. Stars are ordered by the number of detections (truncated to 100 stars). b) Percentage of detections (full catalog) – red line = snow line position.](image)

Plants with high masses are globally well detected. Below a mass of 1 M\(_{\text{jup}}\), the probability of detection is close to zero. Hi-5 is more sensitive to large giant exoplanets.

CONCLUSIONS

1. A catalog of 4002 stars (< 300 Myr) is derived.
2. Synthetic exoplanet systems are generated around these stars using two planet formation models (cold and hot start).
3. With the large AT configuration, more than 30 planets could be detected assuming 20 nights of observations and two stars per night.
4. Yield computation shows that Hi-5 is able to detect more than 50% of the hot-start planets with a mass larger than 4 M\(_{\text{jup}}\).

REFERENCES

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