EPSC Abstracts
Vol. 8, EPSC2013-782-1, 2013
European Planetary Science Congress 2013
© Author(s) 2013

Characterization of the Super-Jupiter κ Andromedae b

M. Bonnefoy (1), J.C. Carson (2,1), T. Currie (3), **C. Thalmann** (4, 5, 1), P. Hinz (6), G.-D. Marleau (1), B. Biller (1), H. Klahr (1), F. Allard (7), J.P. Wisniewski (8), A. Skemer (6), N. Zimmerman (1), J. Schlieder (1), M. Tamura (9), K.R. Covey (10), M. Janson (11), M. McElwain (12), and the SEEDS team
(1) Max Planck Institute for Astronomy, Heidelberg, Germany, (2) College of Charleston, SC, USA, (3) University of Toronto, Canada, (4) Swiss Federal Institute of Technology (ETH), Zurich, Switzerland, (5) University of Amsterdam, Netherlands (thalmann@uva.nl), (6) Steward Observatory, University of Arizona, AZ, USA, (7) CRAL-ENS, Lyon, France, (8) University of Oklahoma, OK, USA, (9) National Astronomical Observatory of Japan, Tokyo, Japan, (10) Lowell Observatory, Flagstaff, AZ, USA, (11) Princeton University, NJ, USA, (12) Goddard Space Flight Center, Greenbelt MD, USA.

Abstract

We present the results of an in-depth photometric analysis of the substellar companion κ Andromedae b. Expanding on the $JHKL'$ photometry presented in our discovery paper [1], we obtained high-contrast images of the companion at 2.146, 3.776, 4.052, and 4.78 μm using the Keck NIRC2 and LBTI LMIRCam facilities. Furthermore, we gathered accurate near-infrared photometry of the host star in order to recalibrate the previously taken high-contrast images. This allowed us to compile a comprehensive set of constraints on the companion's spectral energy distribution (SED), and to compare these data to the spectra of both real benchmark objects as well as PHOENIX-based atmospherical model calculations. Finally, we used a wide range of formation models and initial conditions to constrain the companion mass. We find that the new results fit well with the predictions from the discovery paper, though the comprehensive formation analysis extends the range of possible companion masses deeper into the brown dwarf territory.

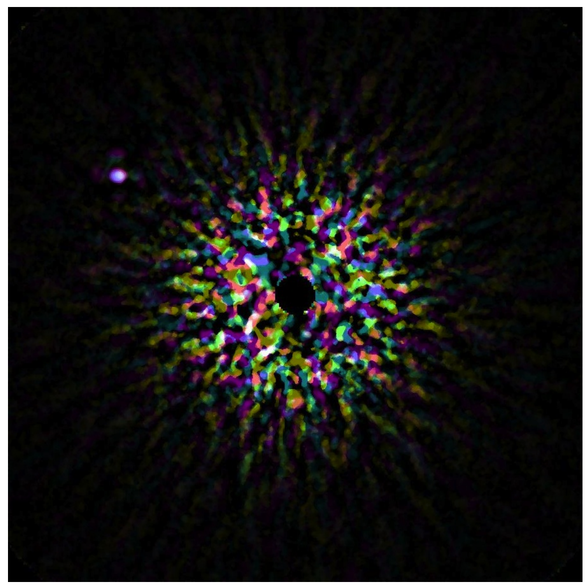

Figure 1: A false-color superposition of the JHK-band high-contrast images in which the Super-Jupiter κ Andromedae b (top left) was first discovered within the residual speckle halo of its host star (center). The neutral color of the companion signal illustrates the fact that it is consistently detected in all three bands.

1 Introduction

We recently presented the direct-imaging discovery [1] of a substellar companion to the late B-type star κ Andromedae as part of the SEEDS (Strategic Exploration of Exoplanets and Disks with Subaru/HiCIAO [2]) survey with Subaru HiCIAO [3]. The companion was shown to exhibit common proper motion with its host star, and a first photometric analysis in the $JHKL'$ bands indicated a temperature of ~1700 K as well as a model-dependent mass of ~13 $M_{\rm Jup}$. With a mass of 2.4–2.5 $M_{\rm Sun}$, the host star κ Andromedae is amongst the most massive known host stars of a planet or brown dwarf companion. The estimated range of companion masses straddles the theoretical limit of ~13 $M_{\rm Jup}$ formally separating planets from brown dwarf companions. However, given the low mass ratio of the system (0.5%), we noted that a more physically meaningful classification for this companion may be to associate it with the emerging new class of companions found around massive stars by direct imaging and Doppler spectroscopy surveys, for which we coined the term 'Super-Jupiter'.

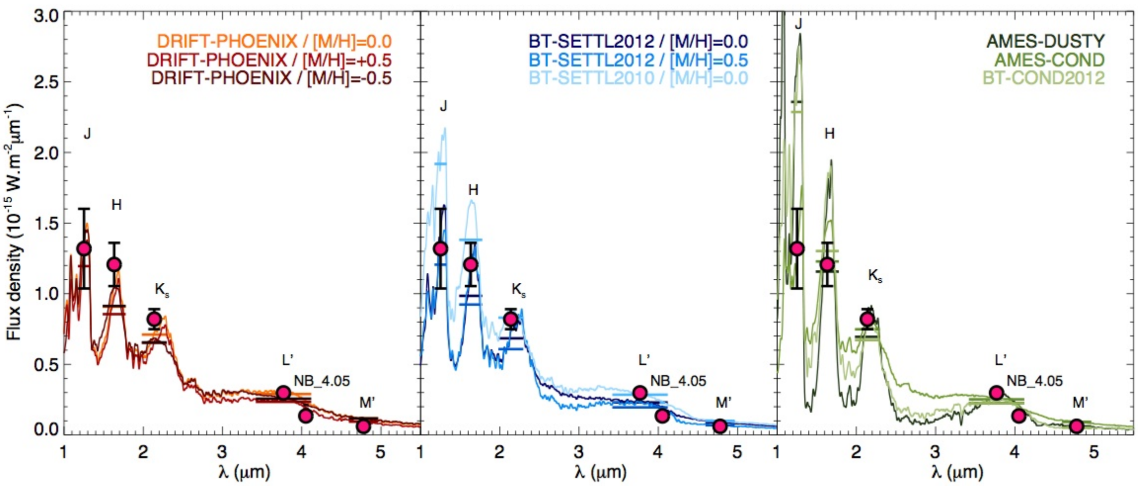

Figure 2: Best-fit synthetic flux (horizontal bars) to the spectral energy distribution of κ And b (pink dots) considering the DRIFT-PHOENIX models with three different metallicities (top panel), the BT-SETTL models (middle panel), the AMES-DUSTY, AMES-COND, and BT-COND models (bottom panel). The corresponding synthetic spectra are overlaid in each panel.

2. Observations and Results

A full paper describing the new data sets and our extensive analysis is in preparation at the time of writing, and is expected to be published by the beginning of the conference (Bonnefoy et al. 2013 in prep.). The preliminary results include:

- The body of photometric data agrees well with empirical and theoretical expectations for a companion with $T_{\rm eff} = 1800 \pm 100\,{\rm K}$ and $\log g = 4.5 \pm 1.0$, consistent with the predictions in the discovery paper.
- Hot-start models imply companion masses just below the theoretical deuterium-burning limit nominally separating planets from brown dwarfs, whereas warm- and cold-start models imply masses above this limit.
- We extended the range of possible system ages up to 150 Myr, which allows for companion mass solutions of up to $\sim$35 $M_{\rm Jup}$.
- We find that gravitational instability in a disk offers a plausible scenario for the *in situ* formation of κ Andromedae b.

Acknowledgements

We thank the LMIRCam instrument team for operating the instrument during our observations. We are gratefull to Christian Helling, Soeren Witte, and Peter Hauschildt for developing and providing the DRIFT–PHOENIX models. We thank Anne-Marie Lagrange for checking for past SOPHIE observations of κ Andromedae A. This research was conducted in part using the Mimir instrument, jointly developed at Boston University and Lowell Observatory and supported by NASA, NSF, and the W.M. Keck Foundation.

References

[1] Carson, J., Thalmann, C., Janson, M., et al. 2013, *ApJL*, 763, L32

[2] Tamura, M. 2009, American Institute of Physics Conference Series, 1158, 11

[3] Suzuki, R., Tamura, M., Suto, H., et al. 2009, American Institute of Physics Conference Series, 1158, 293