EPICS: imaging exo-planets with E-ELT

Raffaele Gratton, Markus Kasper & Cristophe Verinaud
Science Motivation

The EPICS instrument shall be optimized, and trade-offs made, based on the following prominent science cases:

1. Young self-luminous gas giants in star forming regions or young associations. *Determine frequency and mass distribution of giant planets*

2. Detection and characterization of mature gas giants at orbital distances between ~5 and 15 AU in the solar neighbourhood (< ~20 pc)

3. Imaging and characterization of warm or young Jupiters that have been previously discovered by radial velocity searches or direct imaging with smaller telescopes. *Understand giant planets’ atmospheric composition and structure*

4. Detection and 1st order characterization of warm Neptunes and massive rocky planets and super-Earths around very nearby stars (≤ 10pc) with the ultimate goal of detecting such planets located in the HZ (for M-dwarfs and very close systems < 4 pc)
Top Level Requirements

6a Contrast Requirements Y-H band (10h telescope time, reference seeing conditions, 5s detection):

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<tr>
<th>Brightness ratio at Distance [mas]</th>
<th>30</th>
<th>100</th>
<th>300</th>
<th>Limiting stellar magnitude I band</th>
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<tr>
<td>Science Case 1</td>
<td>$10^{-6}$</td>
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<td>9 (goal 10)</td>
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<td>Science Case 2</td>
<td>$2 \times 10^{-9}$ (goal $10^{-9}$)</td>
<td>$10^{-9}$ (goal $4 \times 10^{-10}$)</td>
<td>$7$ (goal 8)</td>
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<td>Science Case 3</td>
<td>$10^{-8}$</td>
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<td>$7$ (goal 8)</td>
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<td>Science Case 4</td>
<td>$2 \times 10^{-9}$ (goal $10^{-9}$)</td>
<td>$10^{-9}$ (goal $4 \times 10^{-10}$)</td>
<td>$5 \times 10^{-10}$ (goal $2 \times 10^{-10}$)</td>
<td>$5$ (goal 6)</td>
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**Top Level Requirements**

*6b* Contrast Requirements I-z band (10h telescope time, reference seeing conditions, 5s detection, for differential signal contrast \((I_1(\text{planet})-I_2(\text{planet}))/(I_1(\text{star})+I_2(\text{star}))\) where \(I_1\) and \(I_2\) are fluxes in two spectral bands (on/off CH4 absorption) or \(I_{\parallel}\) and \(I_{\perp}\) for polarimetry:*

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Detection of rocky planets
Giant planets from RV surveys
EPICS Consortium

ESO (PI institute, M. Kasper): Management, coro, HOT facility, science
LAOG (Co-PI institute, C. Verinaud): Management, simulations, XAO+FPWS, system design
LAM: Coro, DZ
LESIA: Coro, SCC
LUAN: Coro
Padova observatory: IFS, science
Oxford University: IFS
ASTRON, UvA, UU: ZIMPOL
ETH Zurich: ZIMPOL
ONERA: wavefront control consulting
MPIA: IFS DRH
Garching, Feb 19, 2008

EPICS concept

DEFORMABLE MIRROR: $3 \times 10^4 \text{act} 3 \text{kHz}$

WAVE-FRONT SENSOR (PYRAMID)

RTC

INSTRUMENTAL ERRORS CORRECTION

Beam with Telescope AO correction

Additional corrector

CORONAGRAPHS

REFERENCE

WFS

INSTRUMENT

REFERENCE

WFS

post-corono

INTEGRAL FIELD SPECTROGRAPH

Differential Polarimeter

SELF-COHERENT CAMERA

- Integral Field Spectrograph
- Differential Polarimeter
- Self-Coherent Camera
Laboratory demonstration of accurate and efficient nanometer-level wavefront control for extreme adaptive optics

Lisa A. Poyneer, Daren Dillon, Sandrine Thomas, and Bruce A. Macintosh

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2University of California Observatories (UCO) Lick Observatory, Laboratory for Adaptive Optics, University of California, Santa Cruz, 1156 High Street, Santa Cruz, California 95064, USA

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Received 19 September 2007; revised 21 December 2007; accepted 4 January 2008; posted 15 January 2008 (Doc. ID 87659); published 19 March 2008

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**Phase plate correction**

Fig. 7. Radial averages of the spatial PSD of residual error in the case of correcting an atmosphere-like phase plate after calibration of references. The WFS–FTR references were updated using the residual phase measurements provided by the PSDI. This substantially improves the depth of the dark hole, and most of it is corrected to the 0.5 nm rms level, equivalent to the PSDI correction.