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# MagAO-X: a pathfinder for GMT extreme-AO and the search for life with the ELTs

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## Abstract

Searching the atmospheres of nearby terrestrial planets for spectroscopic signs of life is one of the key science goals of astronomy for the next few decades. High-contrast direct-imaging with ground-based telescopes may play a large role in this, however the required significant improvements in wavefront sensing (WFS) and control (WFS&C) performance have yet to be proven on-sky. One system designed specifically to test WFS&C advances is the Magellan Adaptive Optics eXtreme (MagAO-X) instrument.

MagAO-X is a 2040 actuator, 3.6 kHz extreme adaptive optics (ExAO) instrument on the 6.5 m Magellan Clay telescope. It is optimized for visible and near-IR high contrast imaging (currently working from 500 nm (g band) to 1350 nm (J band)). MagAO-X employs a modulated pyramid WFS, which controls 1600 linearly independent modes. The instrument includes classical Lyot, Phase Apodized Pupil Lyot, and Phase Induced Amplitude Apodization (PIAA) Lyot Coronagraphs. A separate non-common path deformable mirror (DM) in the coronagraph provides dedicated low-order WFS&C and higher-order focal plane WFS (including coronagraphic dark holes with 1e-8 achieved in the lab). Science focal planes include dual-EMCCD spectral differential imaging, the VIS-X IFU, and an MKIDS IFU (XKID). MagAO-X has now detected several planets at H-alpha (656 nm) with new candidates undergoing follow-up, is conducting small inner working angle observations of circumstellar disks in scattered light, and serves as a laboratory demonstrator for new technologies (including GMT phasing). Additionally, the GMT GCLEF spectrograph will be deployed early to Magellan, and will be fiber-coupled as an IFU to MagAO-X offering up to R~400,000 visible spectroscopy with 20 mas spatial resolution.

We will present the current status of MagAO-X, review science results to-date, and describe our ongoing Phase II upgrade program. Phase II consists of major upgrades to the coronagraph and its WFS&C system, and is focused on perfecting the ability to image nearby planets in reflected light – with an ultimate goal of directly detecting Proxima b.

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**Keywords:** adaptive optics, wavefront control, coronagraphs, high, contrast imaging, exoplanets