CURRENT AND NEXT-GEN INSTRUMENTATION FOR EXOPLANET RESEARCH.

R. G. Strausbaugh[1], N. R. Butler[1], and R. L. Jackson[1] [1]Arizona State University.

Introduction: It has been shown that exoplanets can be detected in a number of ways. Transit detection is the most useful method with regards to astrobiology.

Space-based, and large ground-based, telescopes have been able to detect exoplanet transits in large numbers. Once these exoplanets have been identified, follow up measurements can be done to gather more information. With regards to extra-terrestrial life, the most important information gleaned from exoplanet transits is atmospheric information. Using primary and secondary transits [1] the spectroscopy of an exoplanet's atmosphere can be obtained.

A new type of infrared (IR) detector has been tested for use in transient research. This Indium Gallium Arsenide (InGaAs) detector has a few advantages over the Mercury Cadmium Telluride (MerCad) detectors commonly used in IR astronomy.

IR detectors such as the one tested are of particular interest due to their mitigation of limb-darkening effects which plague optical transit work [2]. Many of the biosignatures of life that can be detected in an exoplanet's atmosphere are emitted in the IR [3].

The tested InGaAs detector can be mounted on an 18-inch Newtonian telescope and a 12-inch Cassegrain telescope. This configuration is ideal for quick follow-up of transient detections.

The 18-inch (and possibly an array of 18-inch telescopes) will be working with several new telescopes coming on-line within the next few years. The DDOTI (Deca-Degree Optical-Transient Imager) has been funded, with construction planned to be completed later in 2017. An IR counterpart, DIRTI (Degree InfraRed Transient Imager), has also been proposed.

InGaAs IR Detector: The InGaAs detector is manufactured by Goodrich, and was initially designed for military purposes. The detector has 320x240 pixels, each measuring 40x40 microns. Quantum Efficiency testing of the camera showed 80-90% detection through the wavelengths of 900-1700nm.

The dark rate of the detector was tested at room temperature to be $4.7x10^9$ e/s/cm^2, similar to other InGaAs detectors [4][5]. This dark rate is acceptable for astronomical work at room temperature; MerCad detectors must be cryogenically cooled [6] to achieve useful dark rates, greatly increasing costs.

New software called ICACTI (Infrared Camera for Astrophysical and Cosmological Transients Interface) was developed for the InGaAs detector to be useful in scientific research.

Current Telescopes: The current telescopes available for testing and development are an 18-inch JMI telescope and a 12-inch Meade telescope. Both scopes are highly mobile, and can be used for testing in the city for convenience, or at a dark site for improved data quality.

18-inch JMI. The main telescope used for on-sky testing of the InGaAs camera was, an 18 inch Newtonian telescope, f/4.5, with a split ring, equatorial mount produced by JMI. The size of the InGaAs pixels when mounted on the 18-inch scope are 4 arc seconds per pixel; the entire FWHM of a star can fit within this pixel size, limiting the effects of pixel to pixel variations. The entire field of view of the camera on the 18-inch scope is about one-third of a degree (~20 arc minutes). The InGaAs detector mounted on the 18-inch telescope can achieve a magnitude of 11.25 in 60 seconds at five sigma confidence levels.

12-inch Meade. A secondary telescope used in testing the InGaAs detector was a 12-inch Meade. This is an f/10 telescope, and can be used with a wedge to switch between ALT/AZ and equatorial mountings. The size of the pixels of the InGaAs detector mounted on the 12-inch scope are 2.7 arc seconds per pixel, with an entire field of view of about 13.5 arc minutes. Attached to the 12-inch, the InGaAs detector can achieve a magnitude of 10.4 at 5 sigma.

Next-Gen Telescopes:

DDOTI (Deca-Degree Optical-Transient Imager). The DDOTI observatory consists of 6, 28cm telescopes working together on a robotic mount. Together the scopes cover a sky area of 67 square degrees. DDOTI will reach a magnitude of 19 at a 5 sigma level in 60 seconds; it will be able to image the entire visible sky to this depth every three hours. These specs make DDOTI ideal for transient detection.

DIRTI (Degree InfraRed Transient Imager). Initial plans with DIRTI involve upgrading DDOTI telescopes by mounting IR detectors in conjunction with optical devices using high efficiency dichroics. Following these preliminary results, a separate IR counterpart to DDOTI could be built.

References: [1] Baskin N. J. et al. (2013) *APJ*, 773(2), 124. [2] Howarth I. D. (2011) *MNRAS*, 418(2), 1165-1175 [3] Seager S. (2014) *PNAS*, 111(35), 12634-12640. [4] Sullivan P. W. et al. (2013) *PASP*, 125(931), 1021-1030. [5] Nagayama T. et al. (2014) *SPIE*, 9154 915410-1. [6] Norton P. (2002) *O-ER*, 10(3), 159–174.