Sodium Laser Guide Star Emulation

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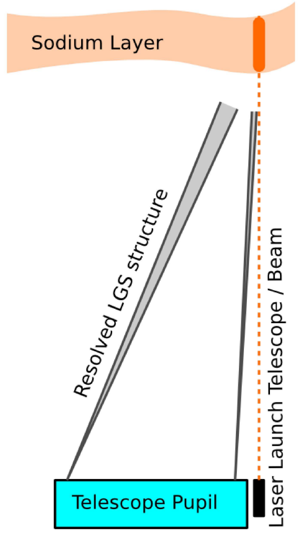
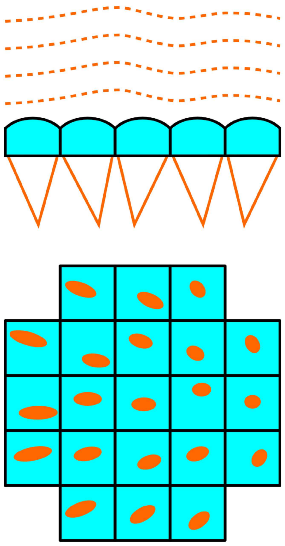
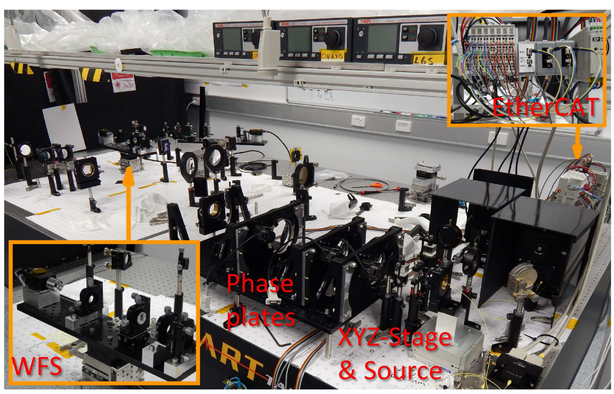
A Sodium Laser Guide Star (LGS) is an artificial source created from Sodium atoms in the upper atmosphere and used for wavefront sensing as part of Adaptive Optics systems. Laser light (589nm) is propagated upward from alongside the telescope, exciting a naturally occurring population of Sodium atoms. Light emitted from the atoms when they return to a stable state creates a ~10km long columns of point sources in the field of view of the LGS wavefront sensor (WFS).





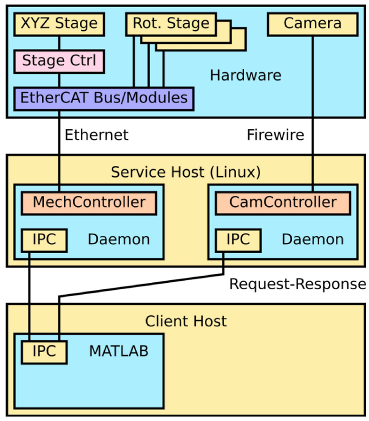
A Shack-Hartmann WFS divides the pupil of the telescope into an array of small patches and focuses the light in each into a spot on an imaging sensor. The tip and tilt of the wavefront over each patch is inferred by measuring the position of the spot. In the case of an LGS WFS the distance of the pupil patch from the laser launch location changes the viewing angle of the column of emitting Sodium atoms, resulting in elongated spots in the image plane of the WFS. This has many implications for the signal quality that the WFS provides as input to the adaptive optics control system.

An adaptive optics non-real-time control system was designed to emulate the properties of the adaptive optics system proposed for the Giant Magellan Telescope (GMT). A single source-camera pair serves for the six LGS of the GMT. This is done by taking six WFS images in sequence, and moving the source between each image acquisition. Spot elongation is emulated by moving the fibre source position and varying the source intensity during each exposure. A precision piezo XYZ-stage is used to position the fibre source in both cases. The effect of atmospheric turbulence is emulated by three phase plates, each mounted on a rotary stage. The plates are moved through small angles between each acquisition cycle and remain stationary during the set of 6 WFS exposures.



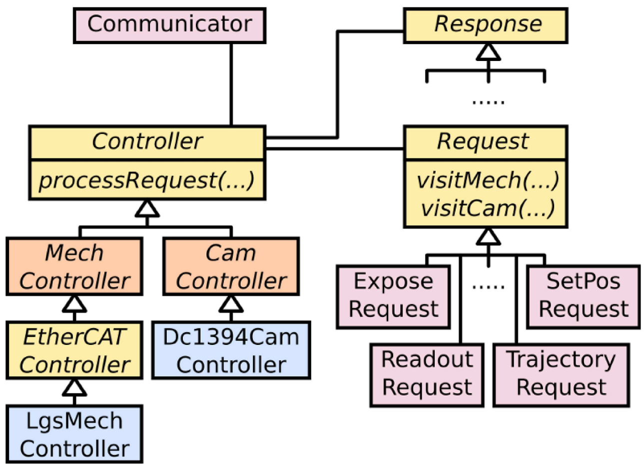
A goal of the system is to allow adaptive optics scientists to test AO wavefront correction algorithms that were developed in MATLAB.

A service-oriented software architecture was used to develop a suite of hardware controllers. Thin clients interact with these services using a simple protocol implemented on top of the ZeroMQ REQ-REP communication model. Integration with MATLAB was enabled by developing thin clients as MEX functions.

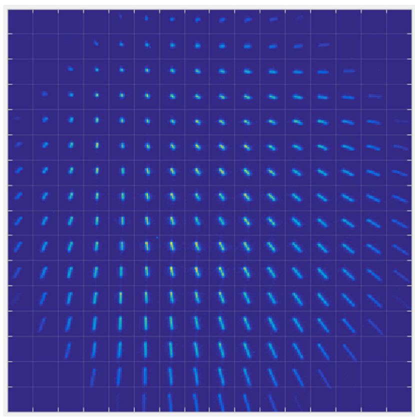


Each service is implemented as a daemon process, each listening for requests on one or more ports. The visitor pattern is applied to double-dispatch specific request types to a particular class of controller.

A framework of core classes supports all services (pink). A concrete controller class is implemented for each type of hardware (blue). Each service-providing daemon uses one concrete controller class.



Initial results demonstrate the system can effectively emulate the physical structure of Sodium laser guide stars, with the images recorded at by the WFS showing the characteristic pupil location dependent elongated structure.



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