RYTSI: A New Way to Do Speckle Imaging

E.P. Horch, Z. Ninkov (RIT), R.D. Meyer, W.F. van Altena (Yale U.)

ABSTRACT

The RIT-Yale Tip-tilt Speckle Imager (RYTSI) is a unique speckle imaging system that can use any large-format CCD as the image recording device. Short exposure images are created by moving the star image in a rapid step-and-expose pattern that covers the entire area of the chip. When this process is completed, all of the recorded images are read out together. The image movement is accomplished with a tip-tilt mirror system enclosed in a compact optics package that sits between the telescope and the CCD system. When used with the RIT 2048 x 2048 pixel CCD camera, approximately 256 (diffraction-limited) speckle images can be recorded in a 16 x 16 grid per full-frame read at a 4 m class telescope. As large-format, high-quantum-efficiency astronomy CCDs continue to improve in terms of readout speed and read noise, they compete very favorably with more traditionally used intensified-CCD (ICCD) systems in terms of signal-to-noise ratio obtainable per frame in speckle imaging applications. In addition, the linear performance of CCDs appears to allow for the possibility of reliable diffraction-limited differential photometry, something that has proved extremely difficult to do with ICCDs. Construction of RYTSI is now nearing completion at RIT, and the module is scheduled for use at the WIYN 3.5 m telescope for the first time later this year. The design and performance are discussed, as well as the future observational program with RYTSI at WIYN.


1. Tip-Tilt CCD Speckle

The idea: use a large format CCD to collect a grid of speckle images over the entire active area of the detector before full-frame readout. Shown above are two possible methods of filling the array.

(a) "typewriter mode" – use the row-shift capability of the CCD to advance two possible methods of filling the array.

(b) "raster mode" - tilt the mirror(s) to deflect the star image in both imaging dimensions (serpentine step method).

2. System Design

Optical design of the system was carried out with the OSLO SIX ray tracing software. The design goal was to create a simple, compact, flexible prototype to demonstrate the "tip-tilt speckle" idea. For example, we will use Melles Griot catalogue lenses and off-the-shelf galvanometric scanning mirrors (from Lasertec, Inc.). A double filter wheel is also being purchased from ISI Systems and will be simply "inserted" into our optics box. Risley prisms (for atmospheric dispersion) will be custom made later this year, but will be rotated at the WIYN 3.5 m telescope for the first time later this year. The design and performance are discussed, as well as the future observational program with RYTSI at WIYN.


3. Testing and Fabrication

The scanning mirror system has been tested in the laboratory, and the step-and-expose capabilities appear to be more than sufficient for the speckle imaging application. Below is an example of a laser speckle spot created in the lab and imaged with the RIT 2048 x 2048 CCD, using a lens system and the scanning mirrors set up on an optical bench. Backlash occurs in the mirror motion when reversing directions, but we have been able to compensate in the mirror control software.

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