A New Mode For CIRCUS: Diffraction Limited Imaging in K and L

Last October, we successfully implemented the high resolution mode on the Circus camera. The optics and software worked well. It now provides a new operational mode on the Circus camera.

Description

This mode gives two scales: .06 arcsec and .11 arcsec per pixel. They correspond to the Shannon sampling for the K and L band. The limited diffraction resolution of the 3m60 are .12 arcsec in K and .023 arcsec in L. Acquisition is of the speckle type: integration time below the coherence time of the speckles, periodic exchanges between the object and its reference. However it is possible to increase the integration time so that we obtain a larger signal-to-noise ratio, in this case, of course, the final resolution would be altered. Data are stored on a Sun station hard disk via Ethernet under Fits format. The system is powerful enough to support integration time down to 16 ms with a 50 per cent efficiency. The good seeing at Mauna kea often allows integration times above fifty ms which give us a yield of nearly one hundred per cent.

Two "quick-look" options are available: the power spectrum computation and the shift and add method. The first gives information checking the acquisition chain (there is a lot of observation biases in speckle). It guarantees that the data will be good for post processing. We can visualize the visibility of the object which is the square root of the power spectrum of the object divided by the power spectrum of the reference (visibility is also the Fourier transform of the autocorrelation function of the object); therefore we have access to structure information (disk, envelop, binarity...). The second method is a simple way to obtain an image of the object, and then all the richness of bidimensional information.

Observation and first lessons

During these two nights, we were able to reach the 3m60 telescope frequency cutoff, it was very spectacular. The seeing was often excellent (between .5 arcsec and 1 arcsec in the optical wavelength) but transparency was poor. A important point was the effect of cosmetic quality of the chip on the speckle signal. Most of the flaws in the power spectrum were well understood during the observations.

As a preliminary test T tauri has been easily resolved on individual images. We observed several objects like the Red Rectangle, RAqr, GI 773.3, a recently discovered close binary in the L band; we did not had enough time to use the other scale.

We are now examining these data and some interesting results are expected because we resolved two objects in real time. The small field of Circus was not a problem. The seeing is good enough so that we never cut its wings. The tracking quality of the telescope was sufficient. Moreover we have a real time quick look that displays an image corrected of camera comestic defaults. In case of low signal it is to be used to supersede the standard quick look to adjust tracking errors. Autoguiding is also a solution, but we have to look for a guide star. The pointing of objects invisible with the guide camera was in fact the only remaining problem; however, it depends on the pointing model of the telescope which could be improved.

Development

To reach the performance limit, it remains to completely understand the low level noise sources. In the next months, a data processing package will be installed at CFHT, providing several techniques of image reconstruction like shift and add, Knox and Thompson, speckle masking. Some improvement in the real time processing will be made too.

The bad transparency during this run can't permit a fair estimate of the real performances. Nevertheless it seems reasonable to say that 4 to 5th magnitude objects can be observed with the present array under good conditions at CFHT. So, a whole range of objects already observed in monodimensional speckle are within our grasp with this new high resolution imaging mode.

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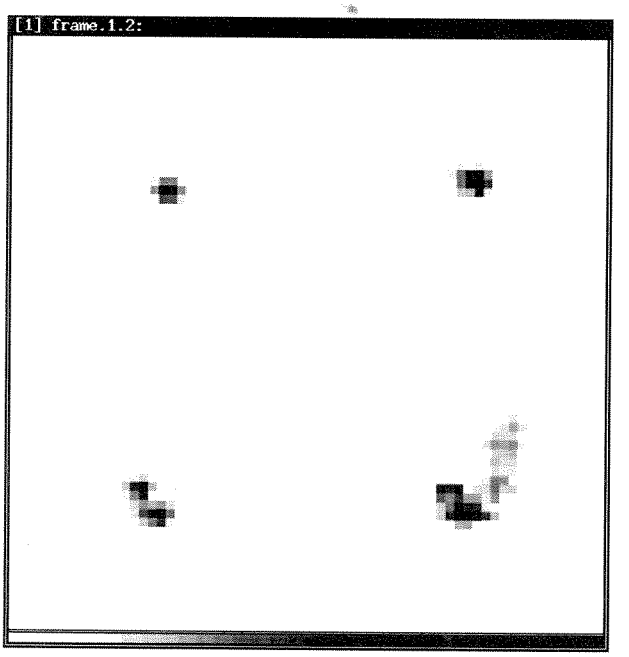

Figure 9: Four frames of speckle images of a single unresolved object showing the statistics. From the top left to bottom right, a range of good to degraded images.

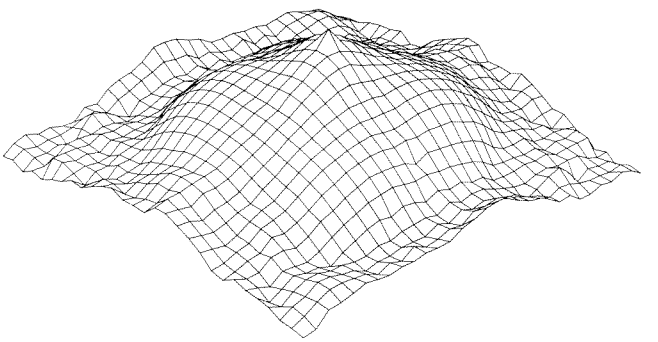

Figure 10: Power spectrum of an unresolved object in a log scale, averaged over 400 frames.