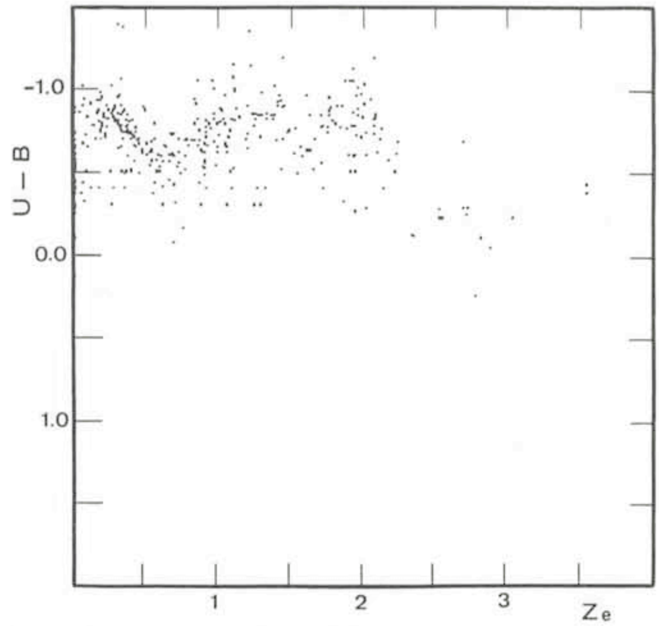

Fig. 5: *Plot of U-B versus Ze for 384 quasars.*

influence by using a standard emission-line quasar spectrum, and get a good approximation of the slope of the continuum. Less accurate than spectrophotometry, of course, but far quicker. As quasars have usually the bad taste of being very weak objects, a wide band photometry is essential to grasp a maximum of those scarce photons.

– The central regions of the nucleus emit, often, a variable amount of energy. The monitoring of that variability is the only way to get information about the sizes of the emitting regions. A simple argument shows that if an object is variable on a time scale of, say, a week, its overall dimensions cannot be much in excess of one light-week. Otherwise, variations concerning different parts of the object would be "averaged" and such a short time scale would not be observed. We are now reaching the day level, and that is, more or less, the lower limit the present models can accept. Discovery of faster variations in quasars would call for a new improvement of those models. So it is extremely important to seek for such fast variations, and to include such observations in a multifrequency programme. As radio, visible and X-ray radiations originate in different regions, multifrequency monitoring should throw new light on the structure of active galactic nuclei of galaxis.

The technical difficulties are great, of course: searching for fast variations, one searches for faint variations. Once again, broad band photometry is the good choice, with a large telescope and as many nearby standard stars as possible, to minimize the unavoidable noise.

What else? Well, we are, regarding the quasar problem, in the data-accumulation phase. Nobody can tell exactly what is a quasar, and it is still necessary to accumulate a maximum of information, and to seek for a maximum of correlations between parameters. It's the time where people plot anything versus anything, and hope to find some New and Universal Truth. . . . Magnitudes are just one of such parameters.

An Infrared Speckle Interferometer

C. Perrier, ESO

Since visible speckle interferometry has been developed ten years ago, efforts have been made to extend this technique to the infrared range for angular size measurements. Using the experience obtained on Kitt Peak by Sibille, Chelli and Lena (1979, *Astronomy and Astrophysics,* **79**, 315), an IR speckle interferometer has been developed at the La Silla observatory in connection with the installation of the IR photometer designed for the 3.6 m Cassegrain focus.

The aim of this article is to describe this system and to present the peculiarities of this observational technique in the light of selected results. But first let us recall the astrophysical motivation for such a work.

The Need for High Resolution at IR Wavelengths

The main motivation is the lack of direct information on the spatial intensity distribution in existing models of the various objects belonging to the group of compact IR sources. Among them, those found in regions of active star formation are probably the most fascinating.

As all their flux is emitted in the infrared, ranging from a few microns up to hundreds of microns, these objects are not reachable with optical interferometry. On the other hand, their size may lie within the diffraction-limited resolution of the large telescopes: Fig. 1 shows the radius of a 10 $M_\odot$ protostar for three representative evolutionary times (taken from Yorke, 1980, *Astron. Astrophys.,* **85**, 215), assuming a diffraction-based limitation i.e. 0.12 arcsec at K (3.5 μm) and 0.27 arcsec at M (4.8 μm), we can see that this object, as far as 0.5 kpc, could be resolved at these wavelengths with a 3.6 m telescope.

Of course, other types of IR objects deserve an investigation at high resolution: IR/OH sources, giants or late-type stars with extended envelopes. For some Miras, size measurements at precise wavelengths corresponding to absorption features may reveal dynamical structures.

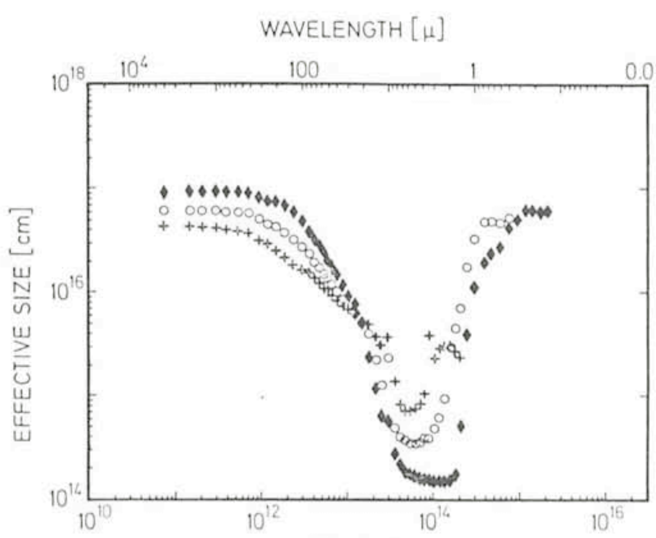

Fig. 1: *Radius as a function of wavelength for a 10 $M_\odot$ protostellar object model at three evolutionary times. At K (2.2 μ) and M (4.8 μ) size is ranging from 1.3 to 6.7 · 10^4 pc (from Yorke, 1980).*

Description of the System

Speckle interferometry has been described elsewhere before. The peculiarity of our system is essentially the use of a single detector because of the current lack of IR detector arrays.

Method

The "specklemeter" is intended to achieve the full resolution of the telescope. Basically it takes and stores instantaneous images of the object. The short exposure of the astronomical image through the turbulent atmosphere freezes the turbulence and preserves, although attenuated, all the information at high resolution, given the pupil diameter D of the telescope.

In our one-dimensional case the image is scanned with a slit fitted to the optimum sampling step (width = $\lambda/2D$). So the points of the resulting scan describe the intensity integrated over image cross-sections and contain all the spatial information along the selected direction of scanning. For freezing the temporal variations, each scan must be of the order of 10–30 ms.

Later on these data are reduced using Fourier transform techniques which allow such a line integral of the source brightness distribution to restore unambiguously a radial power spectrum, final output of the observations.

Acquisition Chain

The system achieved at La Silla makes use of the standard InSb photometer (Fig. 2, modified from 3.6 m IR Photometer User's Manual, A. Moorwood and P. Salinari, 1980). The wavelength range of interest, 2.2– 4.8 μm, is covered by its standard narrow-band filters. Thanks to the IR team in Geneva, some modifications not necessary in photometric mode were included from the beginning, like the use of an off-axis mirror corrected for aberrations and the design of a high-frequency boosted preamplifier. The photometric wobbling process being replaced by scanning, the focal plane wobbling mirror receives here a saw-tooth drive signal.

Due to the high-speed sampling of each scan, a special electronics chain had to be built. With a typical scanning time of 10 ms and a 2 arcsec seeing, the time per scan point is 150 μs. The usual way to read the data from an ESO instrument would result in prohibitive delays (2 ms) between successive readings. In order to avoid building a complex specific module, the chosen solution, as found by Mr. D. Hofstadt, consists in overriding the computer control to allow direct access to the instrument interface (the Camac module). This somewhat delicate operation has proved to be reliable enough to provide an efficient remote control of the instrument thanks to Mr. M. Maugis who succeeded in making the whole chain error-proof and performant. The only drawback is to prevent the computer from being full time accessible; nevertheless, this effect remains hardly visible.

A scope helps for optimizing the signal when the object is not too faint, otherwise a lock-in amplifier, as used in photometry, must be preferred. But both may be necessary for day-time guiding which has been successfully achieved this way.

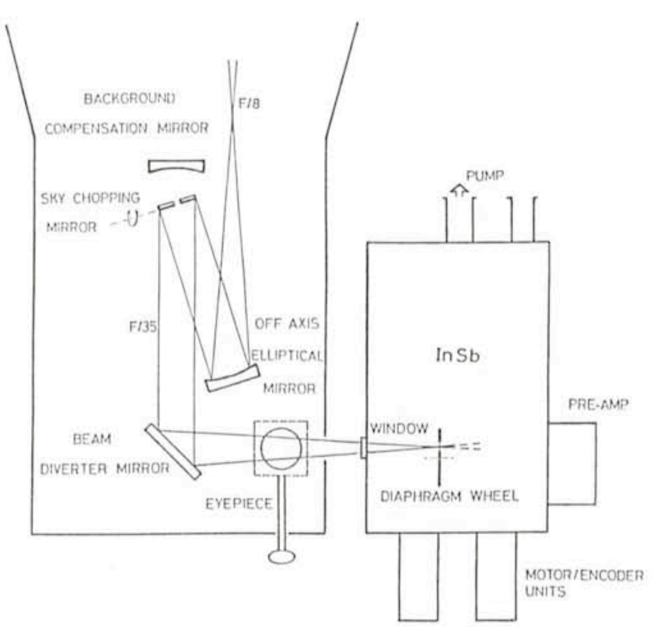

Fig. 2: *Optical configuration of the IR photometer adaptor (see also 3.6 IR Photometer User's Manual).*

Software

The general ESO philosophy, consisting in providing highly interactive programmes, has been followed. As a matter of fact, speckle observations require much effort on the software side because monitoring the incoming data and doing on-line reduction are important requirements. This is mainly due to the almost always variable seeing conditions which lead us to permanently wonder whether some observing parameters should not be modified. In order to make this frequent optimization feasible, and given the fact that the instrument in the Cassegrain cage gets sometimes inaccessible, remote control commands were implemented together with graphics routines and reduction facilities.

The latter are challenging operations for the ESO HP 21 computer which shows here its true limitation. We overcame this obstacle by reducing on-line an amount of data smaller than available, knowing that we were rather lucky to succeed in doing so, whereas this would be impossible with two-dimensional data.

Compatibility with Photometry

One may be tempted to mix both modes (photometry and speckle) in a same night. But the compatibility seems fairly low between the two set-ups. Mr. H. Kastowski managed to make exchanges feasible without waste of precious observing time by designing separate permanent cablings. But still any exchange requires the modification of the scanner setting and possibly the exchange of the HF boosted preamplifier not suited for usual photometric measurements. So sharing time between the two modes have usually been avoided, even if both corresponding programmes which run under the same executive system can be interchanged without loss of data.

Examples of Results

The first observations on La Silla were performed in 1980 and since then a number of objects of interest have been observed, mainly at 4.8 μm because of their strongly reddened colours. In addition to, properly speaking, astrophysical results, a large amount of information concerning the atmospheric behaviour has been obtained and should be useful for a better understanding of the seeing quality at the 3.6 m.

Limiting Magnitudes

Typical individual scans are plotted in Fig. 3: the scanning rate was 9.5 ms for 64 points corresponding to 5.6 arcsec on

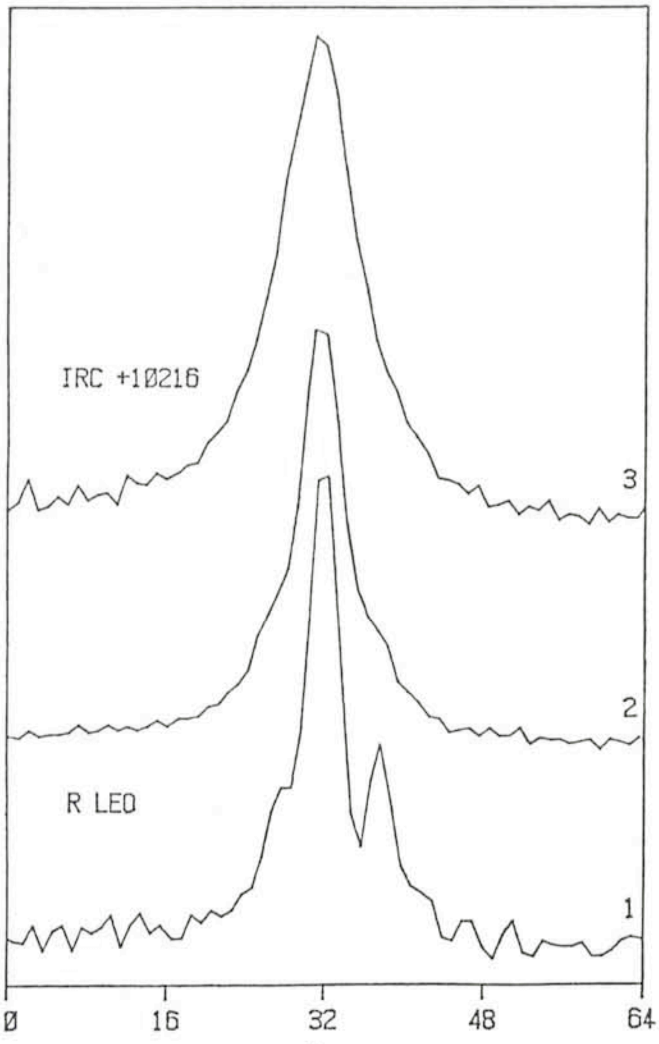

Fig. 3: *Scans obtained in band M with the ESO 3.6 m telescope in October 1980. Sampling period: 87 milliarcsec.*
1 – *Point-like source, the 10 ms scan shows speckles.*
2 – *Same scan as 1 averaged with following ones during 180 ms, speckles are smoothed out.*
3 – *Extended object, the 10 ms scan exhibits no speckles at all.*

the sky. So the maximum sampling frequency (5.7 $arcsec^{-1}$) was larger than the telescope cut-off frequency (3.72 $arcsec^{-1}$ at M) as is preferable for securing an oversampling.

Both objects are late-type stars with negative K and M magnitudes. So these graphs do not represent the usual appearance of individual scans of common and less bright objects. But one can deduce from them the limiting magnitudes M_{lim} in speckle mode and compare to the known photometric performance. With one arcsec seeing, one finds M_{lim} (3σ, 1s) = 4 in agreement with M_{lim} = 3.4 derived from M_{lim} (3σ, 15mn) = 10 given for the photometric mode with a 3 arcsec diaphragm. The slight discrepancy – favourable for speckle mode – comes from the background limitation in photometry, no longer present in the speckle mode where the instrument throughput is reduced. Similarly the same deduction leads to K_{lim} (3σ, 1s) = 8.

M_{lim} (1s) only gives the limitation in the guiding sense when the signal is used for centring; if offset guiding is achieved on field stars, a longer integration is possible, hence fainter objects may be analysed.

Object Spectrum

The final object spectrum contains information on the size of the object up to the cut-off frequency D/λ of the telescope. This makes the value of speckle interferometry obvious even when a single cross-section of the object spectrum is obtained. Such a spectrum is shown in Fig. 4: IRC + 10216 is a carbon star with double shell structure. Because of the non-unicity of the solution describing complex structures in the image, the radial intensity distribution cannot be retrieved in a straightforward way, except on bright objects, where the high signal-to-noise ratio should allow the use of phase-restoration techniques, still in their infancy when applied to astrophysical data.

But one can assert the departure of the object from circular symmetry by exploring different directions of scanning. This explains that we often rotated the Cassegrain adaptor for observing some interesting objects expected to present some assymmetry. This feature offered by the 3.6 m Cassegrain focus is indeed an important advantage of the system configuration.

A Useful New Catalog

A revised Shapley-Ames catalog of bright galaxies by Allan Sandage and Gustav Tammann has just been published by the Carnegie Institution of Washington.

In 1932, Shapley and Ames published their Harvard survey of 1,246 bright galaxies. Their work became the basic listing of bright galaxies; after half a century, it still has a major role in studies of galaxies in the local region.

In the early 1950's, Sandage set out a plan to compile type, magnitude, and redshift data for all galaxies in the original Shapley-Ames catalog. The project, later joined by Tammann, was an outgrowth of the photographic survey of bright galaxies begun at Mount Wilson in 1909 and continued at Palomar after completion of the 5 meter Hale telescope in 1949.

The result of that long-range program is the present catalog, containing data on types and magnitudes for all the Shapley-Ames galaxies and redshift for all but one (NGC 3285). The usefulness of this catalog lies mainly in the list of uniformly determined Hubble type for a large and complete sample of galaxies. Too often, in the literature, the type of galaxies has been estimated on poor photographs producing unexpected results. But another aspect of this work makes it a necessary tool for all astronomers interested in bright galaxies: the listed redshifts are extracted from 430 sources. For 68 % of all galaxies, at least two independent redshift determinations are available, but the velocity of 394 galaxies rests on only one determination and could be in some cases in error. However, it is estimated that the median error is 40 km s^{-1}.

The book also contains 90 illustrations of galaxies exemplifying luminosity classes.

This catalog is a necessary tool as it provides a uniform set of basic data for a large and complete sample of nearby galaxies. It can be ordered from:

Publications office
Carnegie Institution of Washington
1530 P Street, N.W.
Washington, D.C. 20005

Its price is 29 US $.

P. V.