Major Uncertainties about the Atmospheric Wavefront Structure Function

The spatial frequency distribution of the wavefront distortions introduced by the earth atmosphere is of great importance for the behaviour of interferometers and for the wavelength dependence of the seeing disk size. Frequently it is assumed to correspond to a Kolmogoroff distribution which results in the RMS wavefront differences to grow as the baseline to the power 5/6. Serious concerns were expressed at the conference about the validity of the Kolmogoroff distribution. Observations with the two Mt. Wilson interferometers (Mark III and the ISI, see Table 1) give very different results. Whereas the Mark III interferometer indeed gives results consistent with a Kolmogoroff distribution, the ISI researchers find the exponent to decrease from $\approx$ 5/6 to $\approx$ 1/2 for good seeing conditions. This is a very large difference which will have a major influence on the predicted performance of interferometers and large telescopes.

Future Meetings

ESO plans to hold its next meeting in this conference series (High Resolution Imaging by Interferometry III) in the spring of 1994. The topic of adaptive optics, of major interest for interferometry, will be dealt with extensively in the April 27–30, 1992 ESO conference on "Progress in Telescope and Instrumentation Techniques". From January 11–15, 1993 the IAU Symposium No. 158 in Sydney, Australia, on "Very High Angular Resolution Imaging" will focus on interferometric imaging at both optical and radio wavelengths.

PROFILE OF A KEY PROGRAMME

Optical Identification of Celestial High Energy Sources

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The problem of the optical identification of high energy (X-and γ-ray) sources is a classic of modern astronomy. It is only through the optical studies that one can gain complete understanding of objects, galactic and extragalactic alike, which emit a lot of their energy, through thermal and non thermal processes, in photons 1000 or one million times more energetic than the optical ones. For hard X-rays and γ rays the problem is complicated by the source location accuracy, limited by the physics of the detection interaction. In particular, the focussing of photons is only possible if their wavelength is comparable to the surface roughness of the reflecting surface, and this happens, in practice, only up to a few keV.

This is why, in the presence of a poorly positioned high-energy source, one tries to exploit the soft X-ray domain to zero on the possible optical counterparts. Broadly, this has been the strategy adopted in our Key Programme "Optical follow up identification of hard X-ray/soft γ-ray sources discovered by the SIGMA telescope" (see also Bignami et al., 1990). About two thirds of it have already been carried out, and the first

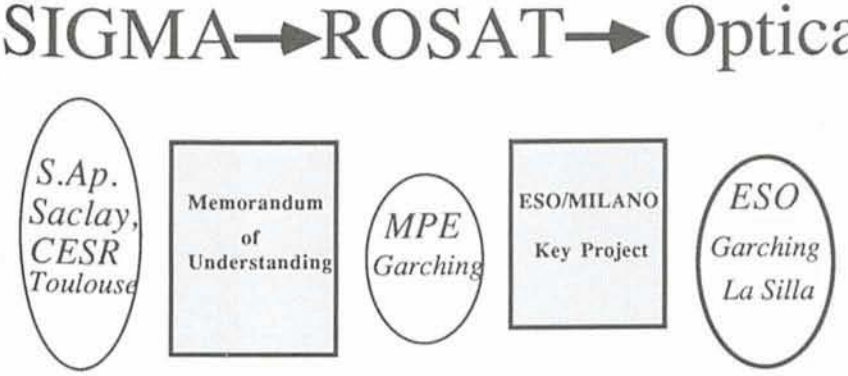

Figure 1: *Strategy of our Key Programme.*

results can be briefly outlined in what follows.

During two observing runs in January and May 1991, we used EMMI at the (ESO) NTT telescope to perform imaging and spectroscopy in our candidate fields, selected following the strategy outlined in our original proposal. As mentioned, the idea is to bridge the gap between the SIGMA hard X-ray energy (>40 keV) range and the optical domain, taking advantage, when feasible, of the location accuracy achievable from the ROSAT soft X-ray "all sky survey". As sketched in Figure 1, this is based on an ad hoc agreement between the proposing team and the Max-Planck-Institut für Extraterrestrische Physik. This method was successfully applied for the first time to the newly discovered GRANAT source called GRS 1758−258, seen by both the French SIGMA and Soviet ART-P instruments (Sunyaev et al., 1991).

GRS 1758−258 lies only 40′ from the bright soft X-ray source GX 5−1 to which previously, for lack of resolving power, the hard radiation was erroneously attributed. Thus, the discovery of this new source is in itself a remarkable achievement of the coded mask technique, used extensively for the first time by the SIGMA and ART-P instruments. The position of the source, measured with ~1′ accuracy by the ART-P telescope, has been dramatically improved thanks to the use of the ROSAT survey data. In fact, using the well-known position of GX 5−1 as a reference, it has been possible to locate GRS1758−258 within a 10″ radius (90 % confidence) error box. Images were obtained with the EMMI red arm using R,I and z filters on May 10, 1991 with the Ford Aerospace 2048 CCD, providing a pixel size of 0.35″. The Guide Star Catalog of the HST was used to perform the astrometry of the field in order to compute the source position and superimpose the ROSAT error box. The outcome is shown in Figure 2 for a 1-m exposure in the I filter. The field is very crowded and several candidates are present down to a limiting magnitude of ~21. The corresponding R and z exposures did not reveal any candidate with peculiar colours. Given the low galactic latitude of this field, absorption is a very critical parameter, so that the next step would be obviously to obtain near IR images of this error box.

During the May observing run, partially hampered by clouds and rain, we concentrated on 1E 1740.7−2942, a soft γ-ray source 50′ from the galactic centre line of sight. This source, already known to be the only high-energy source in the galactic centre region, has been the target of several SIGMA observations which revealed its highly variable nature both in flux and spectral shape. In particular the presence on October 13, 1990 (Paul et al., 1991, Bouchet et al., 1991) of a significant bump in the 300−600 keV region, makes 1E 1740.7−2942 a very plausible candidate for the explanation of (at least part of) the variable e^+/e^- annihilation line measured, over more than a decade now, from the galactic centre region.

Deep images of the region of 1E 1740.7−2942 have been obtained in different filters, adding slightly offset pointings. To position the X-ray source in our images we needed stars fainter than the ones contained in the GSC distributed on CDROM, so that we had to use the original digitized GSC data, which were kindly communicated to us by D. Golombek. In Figure 3 the error circle has been superimposed to the I 14-minute image which appears to be about 3 magnitudes fainter than the SERC I plate presented by Skinner et al., 1991. In fact, stars 1 to 7 are seen here for the first time and their I magnitudes range from about 19 to 21.4.

More objects are visible in the 30 m z filter image shown in Figure 4. The very faint ones are better visible in the contour plot in Figure 5, where a marginally

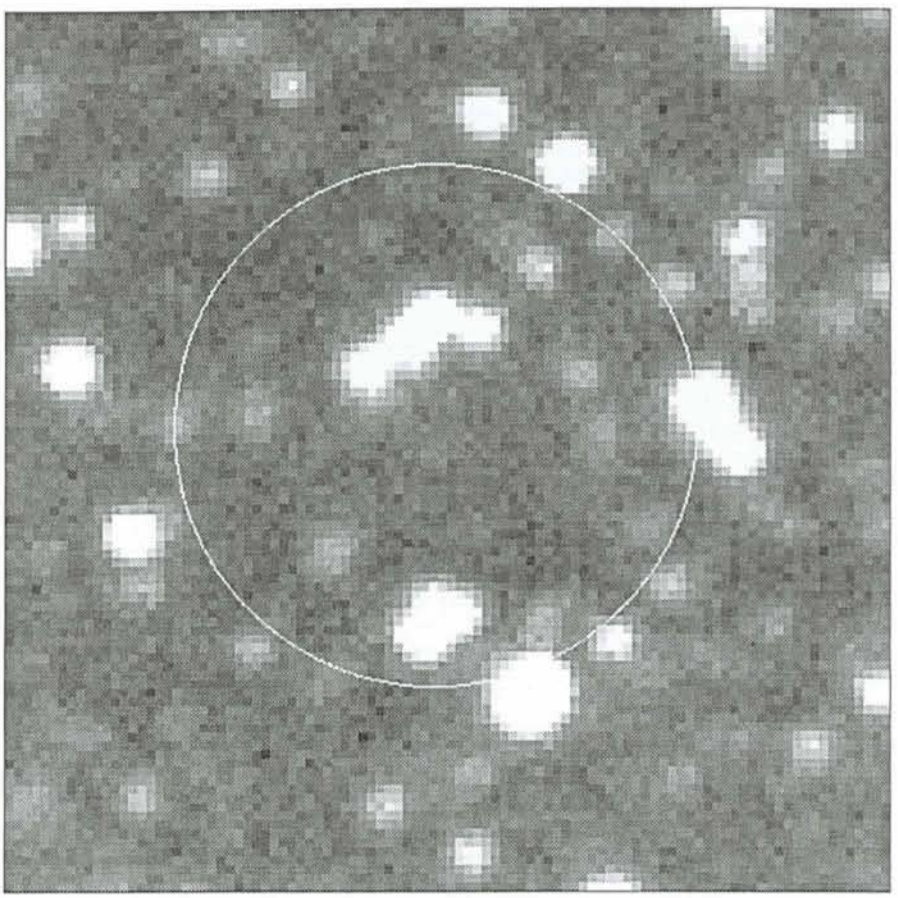

Figure 2: *I-band image of the sky region containing GRS 1758−258. The error box radius is 10 arcsec. North is to the top and East to the left.*

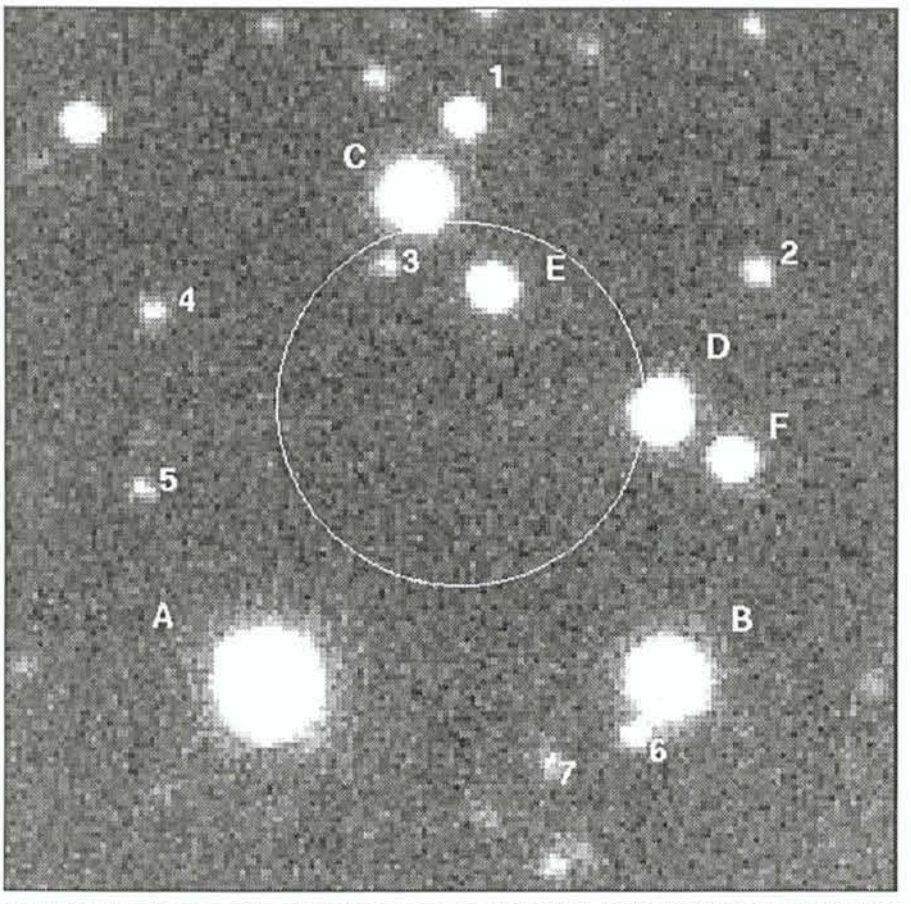

Figure 3: *I-band image of the sky region containing 1E 1740.7–2942. The error box radius is 12 arcsec. North is to the top and East to the left.*

molecular clouds in the centre of our galaxy, so that the search for a more standard counterpart should certainly not be abandoned.

Further detailed investigations of SIGMA sources must still await, at this time, accurate soft X-ray positioning to come mostly from the ROSAT mission. However, the case of Nova Muscae gives another example of an interesting correlation between γ-ray astronomy from Sigma data and ground-based ESO observations, as published by Della Valle et al., 1991.

In the spirit of our Key Programme we have also worked towards the understanding, through the investigation of optical counterparts, of a number of peculiar, unidentified, presumably galactic X-ray sources. This has included, among others, recently discovered GINGA-ROSAT transients, and a number of other serendipitous EXOSAT and Einstein sources. Of particular interest is the case of 1E 120723–5209.8, one of the very few remaining Einstein HRI sources with no firm optical counterpart. The source is at medium galactic latitude, in a non crowded field, and especially interesting because it is located near the geometric centre of the SNR PKS 1255–62. Previous efforts (Matsui et al. 1988) had only yielded a 17-magnitude field G dwarf inside the detected source appears near the weak point-like VLA radio source recently discovered by Prince and Skinner (1991) and proposed as the counterpart of 1E1740.7–2942. The relative positions of our new z-object and of the 0.6 mJy VLA source are such that an association between the two cannot be excluded. Of course, chance coincidence with a field source, both galactic and extragalactic, is still possible.

More details on the optical investigations of GRS 1758–258 and 1E1740.7–2942 can be found in Mereghetti et al. (1991).

Recently, two papers (Bally and Leventhal, 1991; Mirabel et al., 1991) have appeared, suggesting in parallel a model for 1E1740.7–2942 based on a collapsed object embedded in a thick molecular cloud in the central region of the galaxy. The idea is certainly tenable and also important because, if confirmed, it would point to the first example of a new class of galactic high-energy sources. Here again better ground-based observations including IR and radio millimetric could be crucial for an understanding if not of the object itself, probably invisible, at least of its immediate surroundings. However, the chance coincidence of such scenario is rather high, owing to the high density of

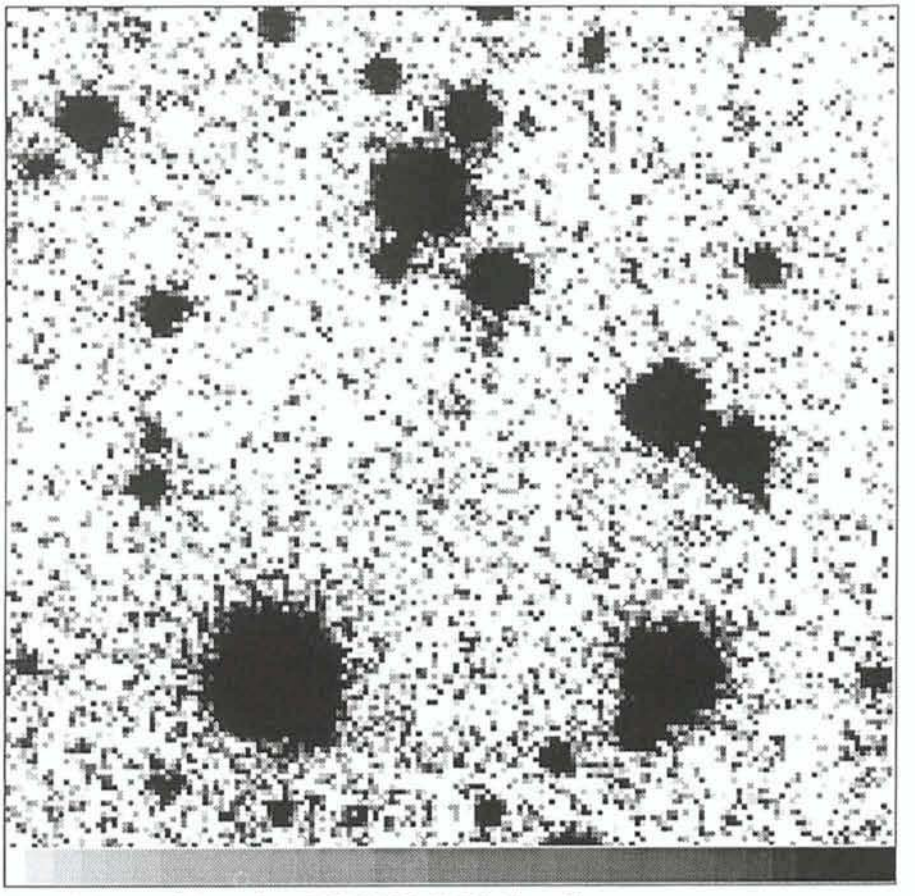

Figure 4: *Image of the region of 1E 1740.7–2942 in the z filter.*

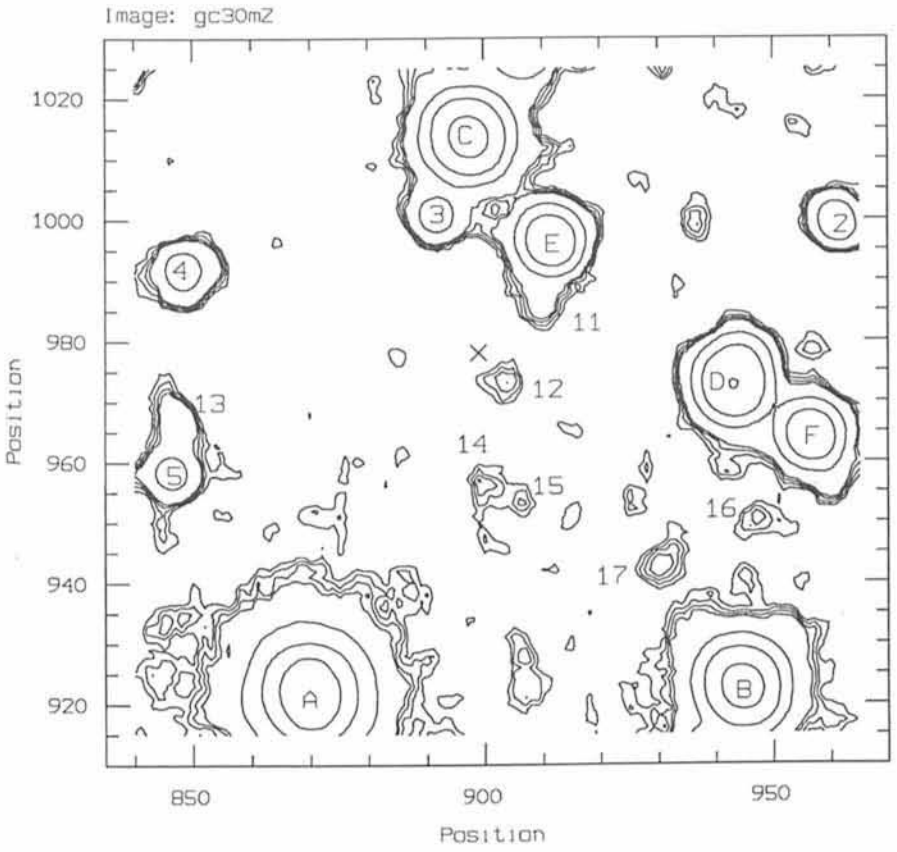

Figure 5: *Contour plot of the image shown in Figure 4. The cross indicates the position of the VLA radio source (α = 17 h 40 m 42.99 s, δ = −29° 43′ 25″ (1950)).*

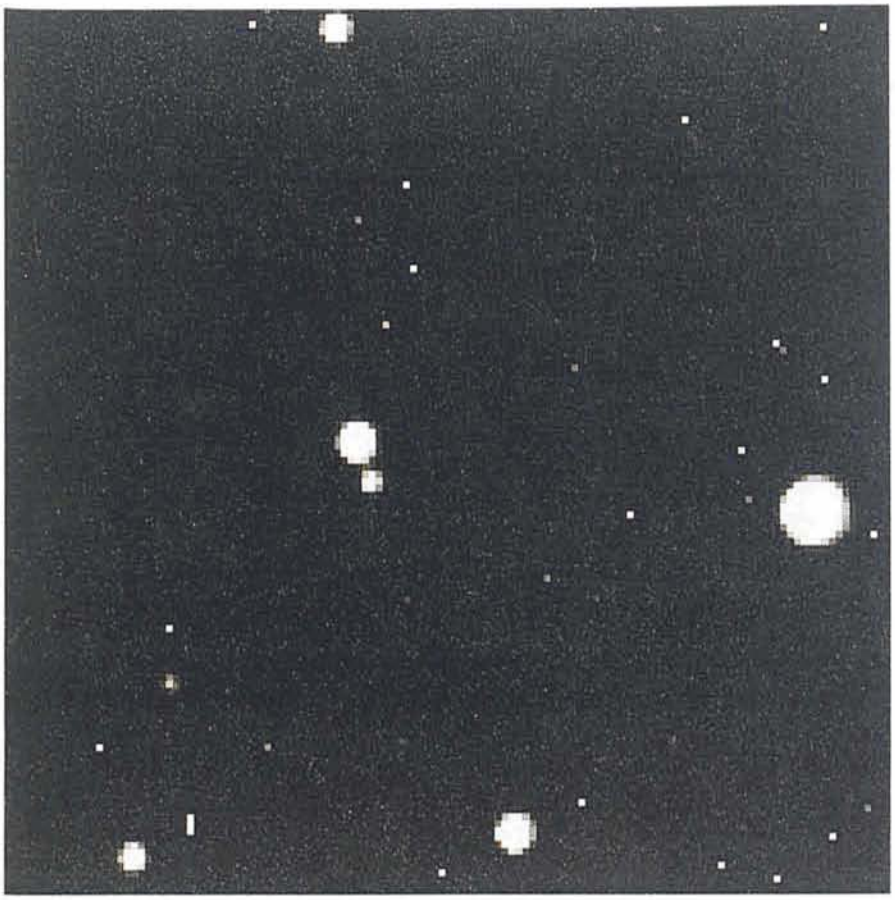

Figure 6: *NTT EFOSC2 V image of 1E120723−5209.8. The field G star (m_v=17.34) and the new candidate (m_v=19.04) are 1.8 arcsec apart. North is to the top and East to the left.*

5″ HRI error box, unlikely to be responsible for the X-ray emission. Our first image with the NTT equipped with EFOSC2 in a night of good-to-moderate seeing (0.9″) showed the presence of a 19-magnitude object 1.8″ from the field star, and thus so far unseen. This is shown in Figure 6. The newly discovered object is very likely to be the X-ray source counterpart, although the preliminary spectrum taken at the NTT, showing no obvious signature, does not allow its immediate identification. The nature of this object could still range from a neutron star, possibly associated with the SNR, to a field BL Lac.

In conclusion, we would feel particularly happy if our Key Programme, beyond its quantitative results, had achieved its purpose of rendering the community aware of the importance of multiwavelength astronomy – from ground as well as from space – for tackling the new objects discovered by high-energy astronomy.

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EMMI, Explorer of the Southern Sky

A new ESO video film has just become available, which describes the ESO multimode instrument, known as EMMI and now mounted at one of the NTT Nasmyth foci. The video explains in some detail the function of this instrument and how it was built. There are also some examples of the astronomical observations which have been made with EMMI.

It can be obtained from the ESO Information Service (address on last page). The cost is DM 70.–. Prepayment is required to account No. 210 2002, Commerzbank München, BLZ 70040041.