Akn 120 is certainly an excellent object for optical photometric and spectroscopic monitoring. It also recommends itself for long-term observations in the radio, infrared and X-ray spatial regions.

Acknowledgements

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Announcement

SECOND ESO INFRARED WORKSHOP

19–22 April 1982

Organizing Committee: R. van Duinen (Groningen), M. Grewing (Tübingen), A. Moorwood (ESO, Chairman), P. Salinari (Florence), F. Sibille (Lyon).

This Workshop is being organized with the aims of reviewing the status and performance of the many infrared groundbased facilities and instruments which have come into operation since the last ESO Infrared Workshop in Sweden in 1978 and to promote discussion on three topics of interest for the future:

- *the infrared astronomical requirements of future Very Large Telescopes on the ground,*
- *the areas in which groundbased and airborne observations can best complement future space missions,*
- *the use of array detectors and the possible spin-offs to be expected from infrared space technology in groundbased and airborne instrumentation.*

An exchange of views in these particular areas is considered to be timely bearing in mind ESO's on-going VLT studies, the imminence of the IRAS launch, the advanced technical state of the GIRL Spacelab project and the widespread interest being displayed in a European Astroplane and ESA's study of an Infrared Space Observatory.

The meeting will be organized around invited reviews of the major projects plus contributions, submitted in response to this announcement, on the capabilities of current instruments and techniques, detector and instrumental developments. In keeping with the desired Workshop atmosphere, however, we intend to devote considerable time to discussion and will particularly welcome contributors interested in expressing their ideas and prejudices on the above themes.

It is hoped that the results will be suitable for publication by ESO. Attendance will have to be limited to around 70.

Further information and application forms can be obtained by contacting

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Observations of the Giant Bubbles in the Large Magellanic Cloud

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G. Monnet, Observatoire de Lyon
M. Rosado, Instituto de Astronomía (Mexico)

Introduction

Deep monochromatic photographs through narrow-band interference filters on nearby spiral galaxies reveal large numbers (50–100) of circular shaped H II regions, with usually weak or absent central emission. They are called by various names; arcs, loops, rings, shells, etc. . . ., and are clearly the two-dimensional projections of more or less spherical bubbles of ionized gas.

This is by no means a new phenomenon: Hubble (1925, *Astrophysical Journal* **62**, 409) had already described three "ring nebulae" in the spiral of the Local Group NGC 6822. But it is the advent of large narrow-band interference filters that had made possible the detection of tens of bubbles in the galaxies in our vicinity. A number of surveys have recently been published, including one by Sivan (1974, *Astronomy and Astrophysics Suppl.* **16**, 163) of our Galaxy with a 1-m telescope and one of M 33 with the Soviet 6-m telescope (Courtès *et al.*, 1981, *The Messenger* No. 23).

In our Galaxy, 21-cm surveys show numerous H I bubbles, and in fact some of the H II rings do have H I counterparts. This phenomenon is thus not restricted to ionized gas, and appears as one of the fundamental ways by which interstellar gas is being shaped in galaxies. Further kinematical and physical studies appear essential to understand the basic processes at work. Our Galaxy, however, is not quite suitable for this kind of studies: Although it has the unique advantage that one can use a home-made telescope, the observer is unfortunately embedded in the galactic disk, which reduces detection, except for close and unobscured regions. In the nearest outer galaxies (M 31, M 33, etc. . . .), the angular resolution of even the largest telescopes is not sufficient for a fair view, and detailed studies would need anyway too many of their severely distributed nights. The Magellanic Clouds—and especially the large one—appear (as usual!) as the best compromise between maximum closeness and unobstructed global view.

N 70

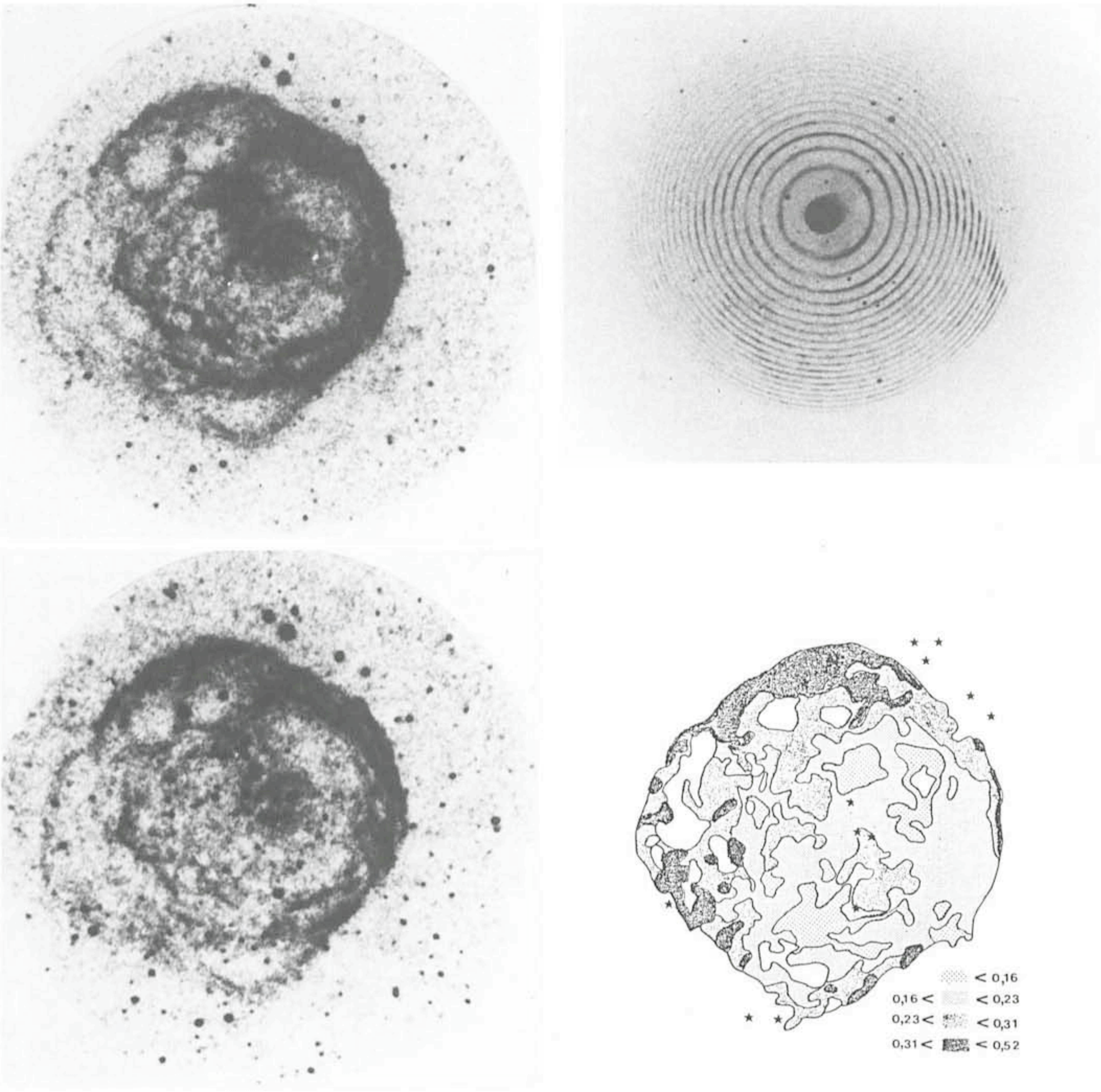

Fig. 1: *N 70.*

All pictures have the same orientation and scale: North at the top – Full circular field 7 arcminutes – The plates have been taken at the ESO 3.6-m telescope.

Top, left: *Photograph in Hα light.* Top, right: *Hα Perot-Fabry rings projected on the nebula; Interference order p = 1053 (Interfrange 285 km s^{-1}).* Bottom, left: *Photograph in [S II] 6717 Å light.* Bottom, right: *Map of [S II] 6717 Å/Hα ratios, using the codes given at the edge of the pictures.*

Observations

For three years we have thus carried out a quite systematic study of the bubbles of the LMC, of diameters in the range 30 to 200 pc.

The basic observational results obtained so far are:

- Radial velocity field of 20 regions with a two-dimensional Fabry-Perot Spectrograph
- Monochromatic photographs of 12 regions in the lines of Hα 6563 Å and [S II] 6717 Å.

We have observed mostly at the 1.52-m ESO telescope, plus a few occasional glimpses with the 3.6-m in the course of a kinematical programme on nearby external galaxies. Full reduction of the Fabry-Perot data is long and tedious, and till now the full velocity field has been extracted for 7 regions only. They give expansion velocities which range between a low 15 km s^{-1} (for N 23) and a respectable 70 km s^{-1} (for N 70 or N 185). A "quick-look" reduction has however been made on

N 148 I

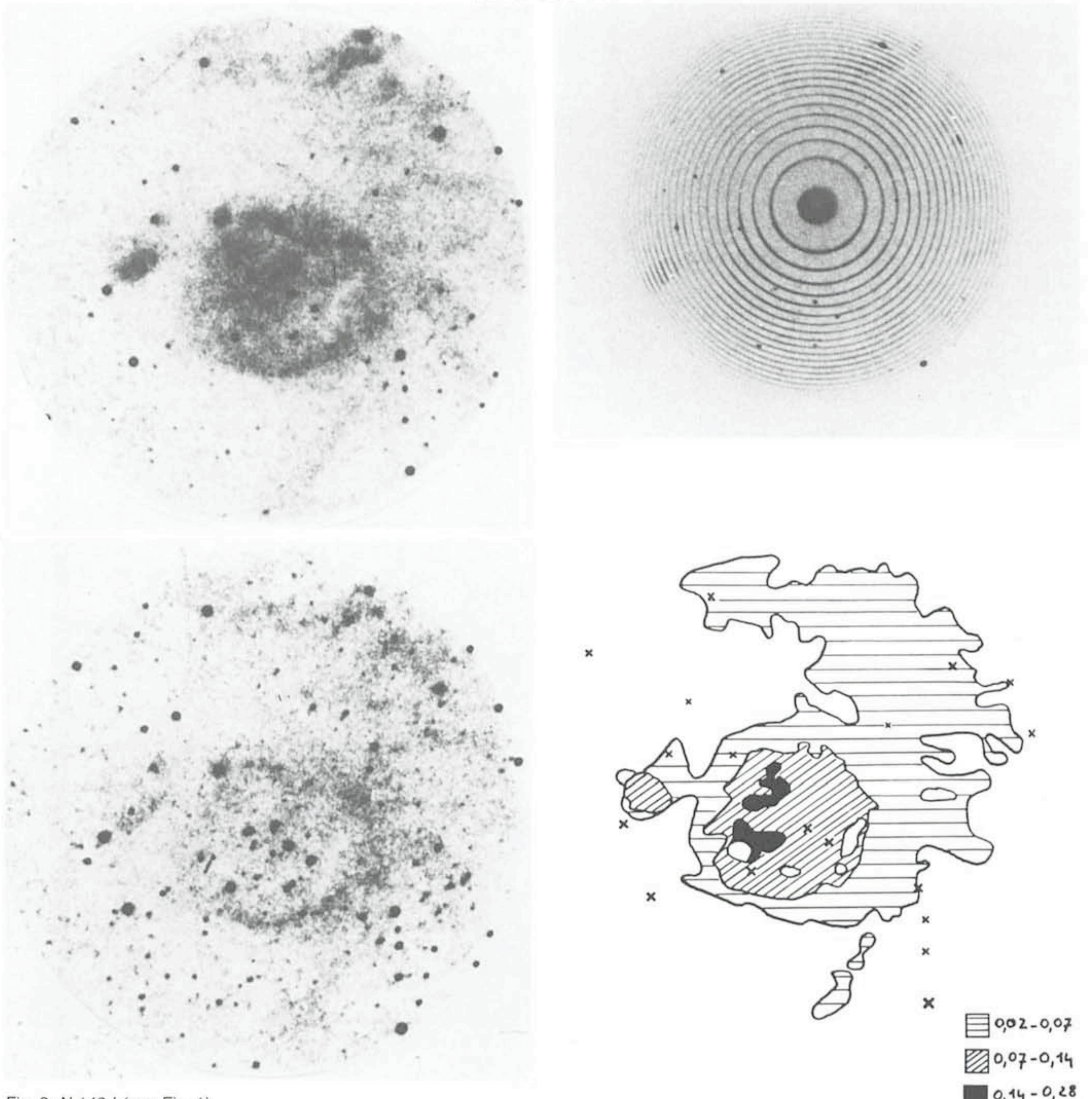

Fig. 2: *N 148 I (see Fig. 1).*

the 20 regions: this gives an estimation of the macroscopic turbulence and thus an idea of the strength of the shocks in the ionized gas.

Reduction of the monochromatic plates was not easy: Even with the 15 Å wide interference filter used they are all plagued with numerous stars. Lleberia (1981, IAU Colloquium, Nice), from the "Laboratoire d'Astronomie Spatiale de Marseille", has implanted a successful programme which automatically gets rid of the stars thanks to a 2-dimension topological test. We have thus been able recently to extract the [S II] 6717/Hα ratios over the 12 nebulae studied. This ratio is also a good indicator of shocks in the interstellar medium: It is < 0.2 for "normal" H II regions in the LMC and > 0.5 for the well-confirmed supernova remnants. Bubbles appear just to fill the gap with ratios between 0.2 and 0.5, indicating in general shocks of medium intensity.

Figures 1 and 2 show two extreme examples of the regions studied: N 70 (Fig. 1) is the prototype of the "strong" bubbles, with a clear crispy filamentary structure, rather large [S II]/Hα ratios, and a large expansion velocity (70 km s^{-1}) superposed to chaotic motions. Its origin, however, is still much debated: old supernova remnant (Rosado *et al.* 1981, *Astron. Astrophys.* **97**, 342) or region driven by supersonic stellar winds (Dopita 1981, *Ap. J.* **246**, 65).

N 148 I (Fig. 2) is a "quiet" bubble with a less pronounced filamentary structure, faint sulfur lines, and a very small turbulence (~ 8 km s^{-1}). It is entirely comparable to a normal H II region. Gentle stellar winds appear as the most likely explanation.

Full correlations between the various physical quantities extracted so far will still need a few months, but the trend is already clear: Filamentary structures, large turbulence and/or large expansion velocities, and high intensity sulfur lines are usually connected, a result that can be seen as blithely encouraging or sorrowly banal, depending on one's mood.

Some abnormal cases yet could happen: N 120—a 20 pc bubble—shows no expansion, a medium [S II]/Hα ratio and turbulence (~ 20 km s^{-1} r.m.s.) and is clearly a young supernova remnant from radio data. N 48 E has the largest [S II]/Hα ratios in our sample (> 1) and is absent from catalogues of non-thermal radio sources.

Conclusion

Through the detailed two-dimensional data—both kinematical and physical—obtained in the course of our study, as well as from the work of other groups, a better picture of the processes at work is slowly emerging. There are some difficult points which, however, cast a gloom over the picture: The origin of the bubbles (SN explosions (Hodge 1967, *P.A.S.P.* **79**, 29), supersonic stellar winds (Gardis and Meaburn 1978, *Astron. Astrophys.* **68**, 189), or even collision with an extragalactic H I cloud (Tenorio Tagle 1979, ESO preprint No. 74)) is quite difficult to assess in each case. Moreover, the range of sizes goes from 20 pc diameter (N 100) to 110 pc (N 70), physical properties and diameters being not related. Some of the largest bubbles after analysis appear just heterogeneous projected structures. Especially lacking is a comprehensive survey with high angular resolution in radio wavelengths to reveal the thermal or non-thermal nature of the objects.

The edge of the bubbles, where, because of its expansion, fresh interstellar matter is being presently compressed, appears as a likely site for generation of new stars and could—according to the so-called "contagion hypothesis" —explain the large-scale chaotic appearance of spiral arms in galaxies. Star formation however appears too erratic in the Magellanic Clouds, and we must turn to more distant, but more regular spirals.

Large-Scale Structure of the Universe

Guido Chincarini, University of Oklahoma

One of the major tasks of astronomy is to find how matter is arranged and distributed in our Universe. On the largest scale it has usually been assumed by cosmologists and by the majority of astronomers that matter is spread uniformly throughout the Universe. This picture is changing and astronomers are recognizing, by focussing more and more on the study of the distribution of visible matter, that the distribution of galaxies is very clumpy on a small scale (pairs and groups) as well as on a much larger scale (superclusters or filamentary structures). It is not clear, in fact, whether any isolated structure exists.

We can preserve homogeneity, but only on a much larger scale than was previously recognized. An observer located in a different part of the Universe could not distinguish one location from the other over scales larger than 50–100 Mpc. The main characteristics would remain the same. For an excellent review and discussion on this matter see Chapter 1 of "The Large-Scale Structure of the Universe", by Peebles (1980).

Evidence that the surface distribution of matter is clumpy has been collected, even if somewhat disregarded until recently, since long ago. I refer to the catalogue by Messier of 1784, to the surveys by the Herschels in the 18th and 19th centuries, to the work by Shapley and Ames (1932, *Harvard Obs. Ann.* **88**, No. 2) and to the later work by Shapley on the distribution of galaxies. Four more recent surveys are of particular importance: The survey of clusters of galaxies by Abell (1958, *Astrophys. J. Suppl.* **3**, 211), the catalogue of galaxies and clusters of galaxies by Zwicky and coll. (1967), the counts of galaxies by Shane and Wirtanen (1967, *Pub. Lick Obs.* **22**, part 1) and the counts in the Jagellonian field by Rudnicki *et al.* (1973, *Acta Cosmologica* **1**, 7). The distribution of galaxies is clumpy also in depth. The first evidence came during the observations of a non-cluster field near the Seyfert sextet located north of the Hercules cluster A 2151 (Chincarini and Martins, 1975, *Astrophys. J.* **196**, 335). However, this evidence was based on a sample of ten galaxies only. The first confirmation of this result was obtained by Tifft and Gregory (1976, *Astrophys. J.* **205**, 696) from the study of a larger sample.

During the seventies two lines of studies developed independently. On the one hand, various astronomers intensified studies on the detailed three-dimensional distribution of galaxies in large regions of the sky; on the other hand, thanks especially to Peebles (1974, *Astrophys. J.* Letters **189**, L51), a sophisticated autocorrelation analysis was developed and extensively applied to the interpretation of counts of galaxies[1]. Previously Totsuji and Kihara (1969, *Publ. Astron. Soc. Japan* **21**, 221) had derived, using an autocorrelation analysis and the catalogue by Shane and Wirtanen, the same coefficients for the autocorrelation function: $g(r) = (r_{\odot}/r)^{1.8}$ with a characteristic length $r_{\odot} = 4.7$ Mpc. Their work went unnoticed for some time.

Ideally we should have a catalogue, or a random subsample of it, complete to a reasonably faint magnitude giving redshifts (possibly accurate to better than 50 km/sec), magnitudes, morphological types and positions. Such a work has been undertaken by Davis from the Center for Astrophysics in Cambridge, Mass.

It appears, today, that galaxies are not distributed at random and that clusters of galaxies are not isolated systems. The distribution of pairs of various separation is described by the autocorrelation function. The function is a measure of the deviation from a random distribution. It also measures the characteristic size of clumpiness and allows confrontation of theories on the clustering of galaxies with observations. Studies on selected regions of the sky show the existence of very asymmetric, often filamentary-like structures, separated by regions which are void of galaxies.

Oort, Arp and de Ruiter (1981, *Astron. Astrophys.* **95**, 7) give evidence that quasars are part of superclusters and Burns and

[1] Peebles' understanding of the cosmological significance of the analysis of the data became a guide to theoretical and observational work and to its physical interpretation.