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May: Gillet/Crowe, Baade/v. Kerkwijk/Waters/Henrichs/van Paradijs, Stalio/Franchini/Porri/Chavarria/Terranegra/Covino/Neri, Spite F./Spite M., Crane/Palazzi/Mandolesi/Blades.
June: Crane/Palazzi/Blades/Kutner, Hubert-Delplace/Floquet/Chatzichristou/Hubert, Danks/Crane/Massa, Pasquini, Houdebine/Panagi/Foing/Butler/Rodono, Gredel/v. Dishoeck/Black.
July: Pottasch/Sahu, Diesch/Bässgen M./Grewing, Didelon.
August: de Vries/van Dishoeck/Habing, Foing/Crivellari/Vladilo/Castelli/Beckman/Char/Jankov.
September: Foing/Crivellari/Vladilo/Castelli/Beckman/Char/Jankov, Prein/van Genderen/Zwaan, Gustafsson/Eriksson/Olofsson/Lambert/Paresce, Thimm/Hanuschik/Schmidt-Kaler.

1-m Photometric Telescope

April: Lorenzetti/Berrilli/Ceccarelli/Nisini/Saraceno, Lorenzetti/Ceccarelli/Liseau/Nisini/Saraceno, Scaltriti/Busso/Origlia/De Francesco/Robberto/Persi/Ferrari-Toniolo/Silvestro, Schultz, Courvoisier/Bouchet, Danziger/Bouchet/Gouiffes/Lucy/Wampler/Fosbury/Fransson, Catalano F.A./Kroll, Madejsky/Appl.
May: Madejsky/Appl, Gouiffes/Cristiani, Reinsch/Pakull/Festou/Beuermann, Courvoisier/Bouchet, Danziger/Bouchet/Gouiffes/Lucy/Wampler/Fosbury/Fransson, Kreysing/Kaelble/Grewing, v.d. Hucht/Thé/Williams, Prévot/Lindgren H.
June: Hahn/Lagerkvist/Magnusson/Lindgren M., Cacciari/Clementini/Prévot/Lindgren H., Terzan, Wink/Greve, Courvoisier/Bouchet, Manfroid/Vreux/Gosset.
July: Brahic/Sicardy/Roques/Barucci, Manfroid/Vreux/Gosset, Brahic/Sicardy/Roques/Barucci, Gouiffes/Cristiani, Schneider/Weiss/Kuschnig.
August: Poulain/Davoust/Nieto, Eriksson/Gustafsson/Olofsson, Danziger/Bouchet/Gouiffes/Lucy/Wampler/Fosbury/Fransson, Di Martino/Zappala/Cellino/Farinella/Davis, Alcaíno/Liller/Alvarado/Wenderoth.
September: Alcaíno/Liller/Alvarado/Wenderoth, Barbieri et al. (2-007-43 K), Danziger/Bouchet/Gouiffes/Lucy/Wampler/Fosbury/Fransson, Zickgraf/Wolf, Gouiffes/Cristiani.

50-cm Photometric Telescope

April: Scaltriti/Busso/Origlia/De Francesco/Robberto/Persi/Ferrari-Toniolo/Silvestro, Schultz, Poretti/Antonello, Thé/Westerlund/de Winter.
May: Thé/Westerlund/de Winter, Stalio/Franchini/Porri/Chavarria/Terranegra/Covino/Neri, Seggewiss/Moffat/Robert.
June: Seggewiss/Moffat/Robert, Kohoutek/Wenskat, Houdebine/Panagi/Foing/Butler/Rodono, Carrasco/Loyola.
July: Group for Long Term Photometry of Variables.
August: Sinachopoulos, Foing/Crivellari/Vladilo/Castelli/Beckman/Char/Jankov, Carrasco/Loyola, Foing/Crivellari/Vladilo/Castelli/Beckman/Char/Jankov.
September: Foing/Crivellari/Vladilo/Castelli/Beckman/Char/Jankov, Group for Long Term Photometry of Variables.

GPO 40-cm Astrograph

April: Elst, Scardia.
May: Scardia, Landgraf.
June: Landgraf, Aniol/Seitter/Duerbeck/Tsvetkov.
July: Aniol/Seitter/Duerbeck/Tsvetkov.
August: Debehogne/Machado/Mourao/Caldeira/Vieira/Netto/Zappala/De Sanctis/Lagerkvist/Protitch-B./Javanshir/Woszczyk.
September: Debehogne/Machado/Mourao/Caldeira/Vieira/Netto/Zappala/De Sanctis/ Lagerkvist/Protitch-B./Javanshir/Woszczyk.

1.5-m Danish Telescope

April: DANISH TIME, Olsen, Della Valle/Rosino/Barbon/Cappellaro/Ortolani/Turatto, Ortolani/Fusi Pecci/Buonanno/Renzini/Ferraro.
May: Ortolani/Fusi Pecci/Buonanno/Renzini/Ferraro, de Jong/Slijkhuis/Hu/van der Bliek, Gregorini/Messina/Vettolani, Ilovaisky/Chevalier/Pedersen, DANISH TIME.
June: DANISH TIME, Calvani/D'Odorico/Zwitter, Reinsch/Pakull/Festou/Beuermann, Calvani/D'Odorico/Zwitter, Mayor et al. (5-001-43 K), Duerbeck/Vogt/Leibowitz, Bandiera/van den Bergh.
July: Bandiera/van den Bergh, Reinsch/Pakull/Festou/Beuermann, Azzopardi/Lequeux/Rebeirot, Gratton/Ortolani, DANISH TIME.
August: DANISH TIME, Mayor et al. (5-001-43 K), Ardeberg/Lindgren H./Lundström, Meylan/Mayor, Bender et al. (1-004-43 K).
September: Bender et al. (1-004-43 K), de Jong/Jørgensen/Nørgaard-Nielsen/Hansen/Goudfrooij, Vettolani/Cappi/Garilli/Gregorini/Maccagni, Ardeberg/Lindgren H./Lundström, DANISH TIME.

50-cm Danish Telescope

April: DANISH TIME.
May: DANISH TIME.
June: Ardeberg/Lindgren H./Lundström, DANISH TIME.
July: DANISH TIME.
August: Group for Long Term Photometry of Variables.
September: Ardeberg/Lindgren H./Lundström.

90-cm Dutch Telescope

April: DUTCH TIME, van Genderen.
May: van Genderen/v.d. Hucht/van Genderen, DUTCH TIME.
June: v. Amerongen/v. Paradijs.
July: v. Amerongen/v. Paradijs, van Paradijs/Strom/van der Klis/Spijkstra, v. Genderen/v.d. Hucht/Schwarz/de Loore, DUTCH TIME.
August: DUTCH TIME, Prein/van Genderen/Zwaan.
September: van Genderen, v.d. Hucht/van Genderen, DUTCH TIME.

61-cm Bochum Telescope

April: Lemmer/Dachs, Schneider/Jenkner/Maitzen.
May: Schneider/Jenkner/Maitzen.

SEST

May: SWEDISH TIME, Israel, de Graauw, Danziger, Reipurth, van der Veen, Schwarz.
June: SWEDISH TIME.
July: Henkel, Wielebinski, Israel, Eckart, Becker, Zinnecker, Israel, Henkel, Zinnecker, Omont, Pottasch, Chini.
August: SWEDISH TIME.
September: Harnett, Combes, Dupraz, Dennefeld, Bujarrabel, te Lintel, Hekkert, Le Bourlot, Haikala, Brand, Wilson, Roland.

IRC + 10216: a Peanut Nebula!

T. LE BERTRE, P. MAGAIN and M. REMY, ESO

1. Carbon Stars with Shells

Carbon stars with low effective temperature (2,000–3,000 K) are thought to be long-period variables evolving on the Asymptotic Giant Branch (AGB). These objects are burning alternately hydrogen and helium in different shells around a degenerate core of carbon and oxygen [1]. Material processed during the helium burning phase is dredged-up by convection to the surface and enriches it in carbon relative to oxygen.

Objects on the AGB are loosing mass due to a combination of two processes: pulsation of the central star and radiation pressure on grains. Consequently, carbon stars are surrounded by shells which also have a carbon-rich composition. The dust which is formed in these shells is expected to be mainly carbon-rich. Its composition is still a matter of controversy: graphite or amorphous carbon are generally proposed, but also silicon carbide (SiC) and

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magnesium sulfide (MgS). Depending on the optical depth of the circumstellar dust shell (CDS), the central star may or may not be observable. In the first case, one speaks of a *carbon mira* and, in the second case, of an *extreme carbon star* (ECS). In fact, it can be shown that there is a continuity between carbon miras and ECS's, and that the latter are only extreme miras undergoing mass loss at a huge rate [2].

One of the most interesting carbon stars is IRC + 10216. This object was discovered as an infrared source in a sky survey at 2.2 μm; it owes its name (IRC) to this circumstance. Early studies [3] showed that it is variable with a period of ~ 600 days and that it appears extremely red with a colour temperature of 650 K over the range 1 to 20 μm; such an energy distribution can only be understood if the central star is surrounded by an optically thick CDS which absorbs stellar radiation and reradiates it at longer wavelengths. Its distance from the Sun is evaluated to be ~ 200 pc. Many molecules have been detected at radio wavelengths in its circumstellar shell and, from modelling of the CO emission, a mass loss rate of ~ 10^{-5} $M_\odot yr^{-1}$ has been derived. Being so near to the Sun and undergoing mass loss at such a large rate, this carbon-rich source is one of the best studied and is often considered as the prototype of ECS.

2. The Shell of IRC + 10216

Its proximity has allowed spatial resolution of its shell. Already in 1969, its optical counterpart was noted to be diffuse and elongated at position angle (PA) ~ 30° [3]. This diffuseness is mainly produced by scattering of stellar photons in the CDS; however, especially at short wavelengths ($\lambda < 0.5$ μm), photons scattered from the interstellar radiation field may also contribute. At infrared wavelengths (2–10 μm), the source is observed to be extended, with a typical size of the order of 1″ or less; in this spectral range, thermal emission by dust in the CDS is dominating. Using one-dimension speckle-interferometric techniques, the source is seen elongated in the North-South direction; furthermore, at 2 μm, it appears asymmetrical, being more extended towards the North and the North-East [4]. A large polarization is also observed in the optical as well as in the infrared ranges. This information is generally interpreted in terms of an axisymmetrical structure with an equatorial disk and polar lobes like in bipolar nebulae.

Although the bipolar nebula hypothesis is attractive, doubts have been cast on it. Molecular-line observations do not present any evidence of deviation from spherical symmetry on scales between 10″ and 60″. Also, deep images of IRC + 10216 were obtained through filters Gunn g, r, i and z, in April 1987, with the 2.2-m telescope at La Silla. They showed an extended structure up to at least 10″ with no evidence of axisymmetry [2]. Furthermore, the central part (< 1″) was seen elongated like in earlier images, but at a PA of 340° instead of 30°. Such a change of PA in less than 20 years is not easily reconcilable with a bipolar geometry which presumes a stable structure like an equatorial disk. Finally, the broad-band energy distribution of IRC + 10216 between 0.5 μm and 3 mm is well understood in terms of a radiative transfer model, consisting of a central star surrounded by a spherical CDS [5]; this result tends to support the idea that the geometry cannot deviate too much from sphericity.

To reconcile the evidences of sphericity (at least on large scales) with the evidences of asymmetry given by imagery of the central part (on scales < 1″), it has been proposed that mass loss occurs in an inhomogeneous manner with no systematic trend [2,4]. Convective cells at the surface of the star may be very large and induce mass loss, at a given instant, in a preferential direction. Due to stellar rotation, they move with respect to the CDS; also, with time these cells evolve, and the matter in the shell appears clumpy with no systematic deviation from spherical symmetry.

In Figure 1, a schematic representation of the inner part of the IRC + 10216 CDS, based on such a proposition, is presented. Matter has been flowing away preferentially from an active spot during the last 20 years. Dust is condensing out of the gas when it reaches a distance, R_c, such that grains can survive in the radiative field; this distance represents the internal radius of the CDS and defines a spherical cavity inside which no dust is present. If condensation temperature is around 1,000 K, the apparent radius of this central cavity is ~ 0.″15, whereas the apparent radius of the star is ~ 0.″02 (for a stellar effective temperature of 2,200 K). The dust density is enhanced in a preferential direction and the images at all wavelengths (i.e. in light scattered or emitted by dust, independently of optical depth) are observed to be elongated in that direction.

Also, in this scheme, the direction of polarization is always perpendicular to that preferential direction as is observed on IRC + 10216. Due to stellar rotation, the elongation, which was observed to be at PA ~ 30° in 1969, appears now at PA ~ 340°; dust which reached condensation point twenty years ago has travelled a distance, R_1 ~ 3.0 10^{-4} pc, and is now at ~ 0.″5 from the central star. Finally, if this representation is correct, the star should appear offset to the South of the nebula; this consequence could give a natural explanation to the asymmetry of the profiles obtained at 2 μm.

3. High-Resolution Imaging

Such a scheme offers an interesting and plausible alternative to the bipolar nebula hypothesis, but is still highly speculative; imagery at high spatial resolution (~ 0.″1 or better) would be necessary to confirm it. The images obtained at the 2.2-m in April 1987 were acquired in good seeing conditions (FWHM of stellar images < 1″) but their spatial resolution was largely insufficient. However, two elements allow to consider improving their quality by numerical treatment. First, a star is close to IRC + 10216 (~ 36″ to the South-East) and could be registered simultaneously on the same CCD frames (see Figs. 1 and 2 in [2]). Second, the pixel size was small enough (0.″6) so that the images of this point source were well sampled. Therefore, it appeared possible to improve the resolution of these images with a deconvolution method using as point spread functions the profiles of the nearby star. In Figure 2, the images deconvoluted by the method of maximum entropy [6] are presented.

The result is striking: one sees a peanut-shaped nebula whose main axis is oriented North-South and concavity is turned towards East. The resemblance

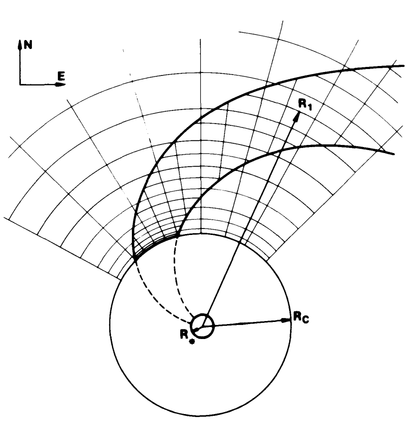

Figure 1: *Schematic representation of IRC + 10216 dust shell (adapted from [2]).* R_x *is the radius of the central star (~ 0.″02).* R_c *is the inner radius of the circumstellar dust shell (~ 0.″15); it corresponds to the distance at which grains are condensing out of the circumstellar gas.* R_1 *indicates the current position of matter which reached the condensation point twenty years ago. North is up and East at right.*

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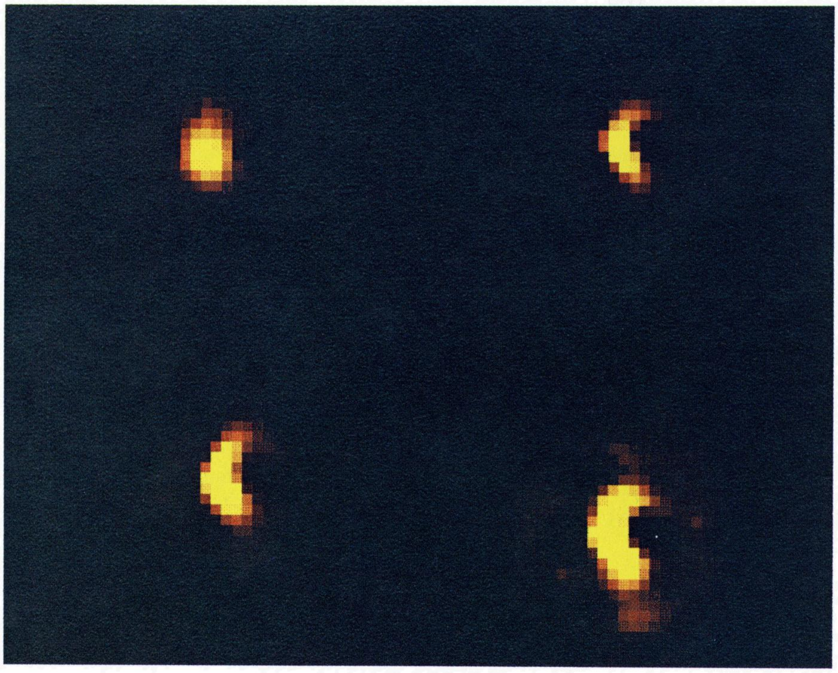

Figure 2: *IRC + 10216 images obtained in April 1987 through Gunn g, r, z and i (clock-wise starting from the upper left corner) and deconvoluted as explained in the text; pixel size is 0″26. The original Gunn r and z frames were presented in [2]. North is up and East at right.*

with the sketch presented in Figure 1 is so flagrant, that we ourselves could not believe it. As IRC + 10216 is more easily observed around maximum, we decided to wait for the next one (expected to occur around November 1988 [2]) and to perform new observations at such phase (with a smaller pixel size) in order to verify the meaningfulness of this result. In the meantime, the algorithm of deconvolution and the code were checked using artificial images. Also, various tests on convergence, consistency, etc. using the real IRC + 10216 images were performed; all resulted positive. For example, one of these tests consisted in rotating an original image by an arbitrary angle, deconvoluting it, then rotating the deconvoluted image backwards and comparing it to the image obtained by direct deconvolution; in all cases, the comparison was satisfactory. Finally, another image-restoration method [7] was used and gave similar results.

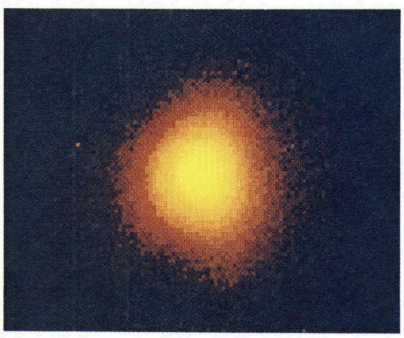

Figure 3: *IRC + 10216 image obtained in December 1988 through Gunn i; pixel size is 0″175. North is up and East at right.*

IRC + 10216 was reobserved on December 16/17, 1988 using the 2.2-m equipped with the recently commisioned CCD no. 15. The individual detector size is 15 μm which translates to a pixel size of 0″175 on the sky. The infrared monitoring performed at the 1-m was indicating that we had, as predicted, just passed the maximum by a few days and that the source was undergoing a maximum brighter than in April 1987. We were therefore expecting slightly larger images for IRC + 10216. On the other hand, the image quality was not as good, being around 1″3, as measured on the nearby star. The frames obtained through the same Gunn g, r, i and z filters were reduced using the standard procedures; the Gunn i image is presented in Figure 3. No basic difference can be noted with respect to the images obtained in April 1987 [2].

The deconvoluted Gunn i image is presented in Figure 4. The same structure as in Figure 2 is again clearly seen. The similarity between the April 1987 deconvoluted images and the December 1988 ones leads to the conviction that the peanut shape is not an observational artifact. Moreover, the fact that this structure is observed at 600 days difference indicates also that it is not a transient, but (on a time-scale of one stellar cycle) a permanent feature of the CDS. The observational confirmation of the scheme proposed earlier by us [2] is important not only because it supports our theses, but also because it contradicts the bipolar hypothesis and, therefore, the models relying on it. It definitively places IRC + 10216 among the normal carbon-rich miras, and not, as sometimes suggested, among the protoplanetary nebulae.

From a more general point of view, it can be noticed that a lot of information is often present in astronomical data which is not exploited. An illustration of overlooked information was given recently in the *Messenger* [8]; our work gives another example. It would surely be worth to apply the same kind of technique to the IRC + 10216 images obtained in the optical range during the last 20 years. Such an investigation could give indications on the recent mass loss history and on the stellar rotation period. Moreover, our work demonstrates the interest in good seeing and good sampling of the point spread function.

4. What is in a Name?

Finally, astronomers are used to give fancy names to their pet objects (derived from their food habits?), e.g.: the Egg Nebula, the Hamburger Nebula and, even, the Rotten Egg Nebula! For IRC + 10216, we propose: the "Peanut Nebula"; as its circumstellar shell is known from observations in the radio range to be rich in organic molecules, we hope this denomination will also satisfy our colleagues from radio astronomy.

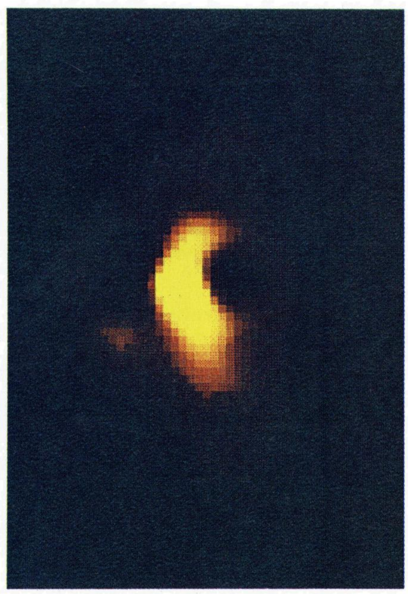

Figure 4: *Same as in Figure 3, but deconvoluted as explained in the text.*

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List of ESO Preprints

December 1988 – February 1989

SCIENTIFIC PREPRINTS

625. (1) C.N Tadhunter, R.A.E. Fosbury, S. di Serego Alighieri: Beamed Ionizing Radiation in Radio Galaxies.
(2) R. Morganti et al.: What Are the Emission Line Filaments Along the Radio Axis of Centaurus A?
Papers presented at the Como Workshop on BL Lac Objects: 10 Years After (September 1988).
626. G. Garay, R. Gathier, L.F. Rodríguez: Radio Recombination Line Observations of Compact Planetary Nebulae. *Astronomy and Astrophysics.*
627. I.F. Alania, O.P. Abuladze, R.M. West: uvbyβ Photometry of Peculiar B and A Stars, Discovered at Abastumani. *Astronomy and Astrophysics, Supplement Series.*
628. E. Gosset et al.: Analysis of the Photometric Variability of WR 40. *Monthly Notices of the Royal Astronomical Society.*
629. P. Molaro et al.: Na I Interstellar Absorption in the Direction of Two LMC Supergiants in the Field of SN 1987A. *Astrophysical Journal,* Letters.
630. G. Meylan, S. Djorgovski: UM 425: A New Gravitational Lens Candidate. *Astrophysical Journal,* Letters.
631. P. Crane et al.: Cosmic Background Radiation Temperature at 2.64 mm. *Astrophysical Journal.*
632. R.M. West, H.E. Jørgensen: Post-perihelion Observations of Comet Halley at r = 8.5 A.U. *Astronomy and Astrophysics.*
633. (1) A.F.M. Moorwood: Near IR Spectroscopy of Active Galaxies.
(2) A.F.M. Moorwood, E. Oliva: Infrared [Fe II], H and H_2 Lines in Galaxy Nuclei.
To appear in Proceedings of the 22nd ESLAB Symposium, *Infrared Spectroscopy in Astronomy.* ESA SP-290 (A.C.H. Glasse, M.F. Kessler and R. Gonzalez-Riesta eds.).
634. E. Covino et al.: EE Aquarii: a Marginal Contact System. *Monthly Notices of the Royal Astronomical Society.*
635. G. Contopoulos et al.: Comparison of Stellar and Gas Dynamics of a Barred Spiral Galaxy. *Astrophysical Journal.*

Guidelines for Authors of Articles for the ESO *Messenger*

The *Messenger* is ESO's house-journal and serves as a link between ESO and the user community. It brings information about scientific and technical developments at ESO and also about administrative measures. At the same time it aims at providing interesting news about astronomy and astrophysics to a broader public, including policy makers, science teachers, amateur astronomers, inside and outside the ESO member countries. At the present time, the *Messenger* is distributed free of charge to about 4,000 addresses (airmail to overseas destinations).

The *Messenger* is abstracted by several services, including AAA.

Since there are limits to the size of each issue, set by the available manpower and by the budget, it has now become necessary to establish a minimum of guidelines for authors. They are not intended to restrict the information flow; on the contrary, they aim at keeping the "fresh" look of the *Messenger*, by ensuring that each issue carries a broad variety of "interesting" and informative articles.

Deadlines

The *Messenger* normally appears at the beginning of March, June, September and December. The corresponding deadlines are 6 weeks before, i.e. on January 20, April 20, July 20 and October 20.

Last-minute, "spectacular" (and short) news items can be received during the editorial process; please contact the editor immediately.

Contributions

Contributions must be written in English. For the benefit of our Spanish-speaking readers, condensed versions of some articles may be published in this language.

Normally, the editor will solicit contributions to the ESO *Messenger* by writing to prospective authors, 6–8 weeks before the next deadline. Unsolicited manuscripts are welcome, but the editor reserves the right not to publish them.

Submitted manuscripts will be checked for obvious, technical errors as far as possible, but it is not possible to undertake major revisions of the language. Therefore, if you are worried about your English, please ask a colleague to help, before you submit your article.

Messenger articles are normally not refereed; however, in certain cases the editor may solicit the advice of other ESO astronomers before accepting an article.

On rare occasions, especially if there are important news items which necessitate last-minute layout revisions, an article will have to be delayed to the next issue. The authors will be informed about this immediately and will have the opportunity to revise the article, if so desired.

Text and Style

All articles brought in the *Messenger* must have some connection to ESO. They will often be based on results from observations at La Silla, but may also concern developments elsewhere of direct implication for ESO programmes.

An article should normally not exceed 4 printed pages, including figures, but shorter contributions, down to a picture with an appropriate caption, are of course most welcome. One printed text page is roughly equivalent to 3.5 double-spaced A4 typewritten pages, 7,000 characters or 1,200 words. The maximum manuscript size is therefore about 10 A4 typewritten pages (20,000 characters or 3,500 words), plus figures.

The style should be light, but informative. **The *Messenger* is no substitute for the professional journals** and its articles should contain less detail and more background than what is usual in scientific papers. Remember that the *Messenger* is read by many people from different fields and with a range of background knowledge from the amateur to the specialist.

A "personal touch" in the form of an associated event, an unusual result, etc., will be appreciated. Similarly, a *Messenger* article may contain information which is not normally included in a scientific article, for instance about technical problems, rather speculative ideas, suggestions for future work, advice to other observers, etc. Early, tentative reports of new results are welcome, but cannot serve to replace proper accounts in referee journals.

An article should not contain more than 10–15 references. Please use the style of *Astronomy & Astrophysics.*

Figures

A maximum of 6 figures is normally allowed per article. They should be submitted in the form of sharp photographic prints or slides. Photocopies of already published figures will not be accepted.

Colour pictures may be used, if the subject justifies the extra cost.

Reprints

No reprints are made of *Messenger* articles, but the author(s), *upon request,* may receive a small number of copies of the issue in which their article appeared. This request should be made when the article is submitted.

TECHNICAL PREPRINTS

1. R.N. Wilson et al.: Active Optics III: Final Results with the 1 m Test Mirror and NTT 3.58 m Primary in the Workshop. *Journal of Modern Optics.*
2. B. Delabre et al.: Astronomical Spectrograph Design with Collimator Compensation of Camera Chromatism (4C). Proceedings of SPIE No. 1055.

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