recover a known object than to detect a new one. But often, orbits and periods are not so well established and there are cases where an object has been lost. That may happen if during the first apparition (the detection event) only a few and maybe not very accurate observations were done. Sometimes the second apparition, when the object has finished its first revolution, is missed for bad weather. Consequently, the orbit is not very well known. During their travel through the solar system, periodic comets may pass near to one of the large planets. Then a drastic change of their orbital elements may take place. Such changes are ruled by pure celestial mechanics, but comets may also undergo other orbital changes not governed by Keplers laws. Such "non-gravitational" forces are not well understood yet.

So the return of a periodic comet and of some minor planets is still an exciting adventure, when such an object, after years, in case of periodic comets maybe up to 80 years and more, comes back to us after its long travel in deep space. That will happen soon with the famous comet HALLEY which after 76 years will visit us again.

And there is a certain tension of course: who will detect it first on its way back to us?

If one has some idea about the orbit, the recovery of these objects is not any more just "fishing" in the sky. One knows at least where to look, and when, what movement could be expected and what magnitude.

The ESO Schmidt telescope was very successful during the year 1980 in recovering comets and minor planets. 6 periodic comets were recovered (table 1) well before their perihelion (nearest approach to the sun) and one minor planet, the long lost HELLA, MP1370 (Schmadel, 1980, *Astronomische Nachrichten,* **301,** 251).

The recovery of the 6 comets was more or less a "routine", but the recovery of minor planet HELLA was something special. This object was observed for the first time in 1935 on a few exposures by Reinmuth in Heidelberg. From then on, for 45 years, the planet was not observed and finally listed as lost.

A careful study by Lutz Schmadel (also from Heidelberg) resulted in a search ephemeris telling us where to look for the object. Using Schmadel's computations, it was possible with the ESO Schmidt to recover minor planet HELLA after 45 years.

TABLE 1

List of periodic comets recovered at La Silla in 1980

P/Forbes	P/Borelly
P/Brooks 2	P/Kohoutek
P/Stephan Oterma	P/West-Kohoutek-Ikemma

Technically the work on the recovered comets and on HELLA has been made possible by a simpel, but powerful device integrated now to the Schmidt guiding system.

Normally, for regular plates, a guide star is put on the cross-wire of the television screen. When this is carefully done, all the stars on the plate will show up as distinct points, and a moving planet or comet will be seen as an elongated trail. One has to realize that doing this for the trailed comets or minor planets would be "wasting light". In this way, the objects we are looking for are moving over the plate and in a simple way one could say that faint objects do not stay long enough on any given spot to tell the emulsion "here I am". Only brighter moving objects can be detected, which mark a sufficiently strong trail. With the ESO Schmidt, for this kind of trailing, the detection limit is about 17th magnitude, depending of course also somewhat on the "speed" of the object. What is done now is the following: the electronic cross-wire on the TV screen is shifted according to the expected movement of the object under study, under computer control. Keeping the guide star on the cross, all stars on the plate will show up as elongated trails but the minor planet or comet under study will become a point. And the detection limit is pushed to the 19th, or even, under good conditions, to the 20th magnitude, depending a little bit on the quality of the precalculated parameters for the cross-movement. So, knowing more or less the movement of the returning object, one may redetect them when they are still faint.

The computer-controlled cross-wire, implemented some time ago to the Schmidt guiding system by the ESO engineers, has been proven to be a very useful and powerful tool in hunting for lost minor planets or recovering periodic comets. A similar system will also be integrated to the 3.6 m triplet guiding system.

For the year 1981 we have a list of candidates to be recovered with the ESO Schmidt telescope, and we hope to be as successful as last year.

H II Regions in Nearby Galaxies

M. Rosa, Landessternwarte Königstuhl, Heidelberg

1. Introduction

In the past decade the interest in emission nebulae in external galaxies has increased significantly. Although the titles of papers on extragalactic research often do not refer explicitely to the fact that the emission spectra of gaseous nebulae have been investigated, a closer look shows that a considerable fraction of that work is based on data obtained from the study of H II regions. In Section 2 I shall try to outline the importance of H II regions in extragalactic astronomy. Section 3 discusses the problems which are still open and form the background of my own work. Finally, some new results are presented and briefly discussed.

2. Previous Work

As soon as closer attention was given to the extragalactic nebulae, observers noted the bright diffuse patches in irregular galaxies and in the arms of spiral systems. As an example Figure 1 shows a blue photograph of the giant Sc galaxy M 101. Very large associations of young stars and H II regions can be seen in the outer parts of the spiral arms. Some of them have their own NGC numbers and their sizes of 10 to 20 arcseconds correspond to linear dimensions of 400 to 800 pc.

Apparently the first one to observe the spectrum of such a giant H II region in an external galaxy was H. Vogel of the Potsdam Observatory in 1890 (!) (cf. Scheiner, Spectralanalyse der Gestirne, p. 254, 1890). In the H II complex NGC 604 in the galaxy M 33 he detected the strong emission lines of Hydrogen and [O III] $\lambda\lambda$ 4960, 5007, thereby establishing the close relationship of this object with galactic H II regions. From that time on, H II regions were used as "wavelength standard sources" to determine the recession velocities of galaxies and the rotation curves of spiral systems. E. Hubble *(Astrophysical Journal,* **63,** 260, 1926) found that the relation between the diameters of the nebulous patches and the apparent magnitudes of the brightest stars involved in these H II regions of M 33 closely resembled a similar relation for galactic H II regions. He used this fact as a piece of evidence for the extragalactic nature of the Local Group galaxy M 33.

Today, the diameters of giant H II regions serve as "yardsticks" in the extragalactic distance scale. They bridge the gap between nearby galaxies, where stellar distance indicators can be used, out to the remote systems, where the Hubble law can be applied. The discrepancy between the present values of the Hubble constant depends strongly on the calibration of diameters and distances of H II regions in M 101 and a few more nearby galaxies.

Most of the more recent investigations of giant H II regions in external galaxies try to derive the physical conditions in these objects. These include the determination of chemical abundances, the study of star formation rates, initial mass functions and heavy element enrichment in galaxies (see for example Audouze, Dennefeld and Kunth, THE MESSENGER No. 22, p. 1, 1980).

3. Basic Problems in the Study of Giant H II Regions

The objective of my research programme is the study of the stellar populations which are located in the cores of the giant H II regions in nearby galaxies and in particular the star formation rates and initial mass functions in galaxies of different types. There are two sources of information: On the one hand we can study the emission spectrum of the gas and derive from these data, with the help of theoretical models of HII regions, the numbers and types of ionizing stars needed. On the other hand, we can directly observe the (scattered) stellar light emerging from the cores of these H II regions to search for stellar spectral features and determine the energy distribution from the far UV to the near IR spectral range. In a final step the

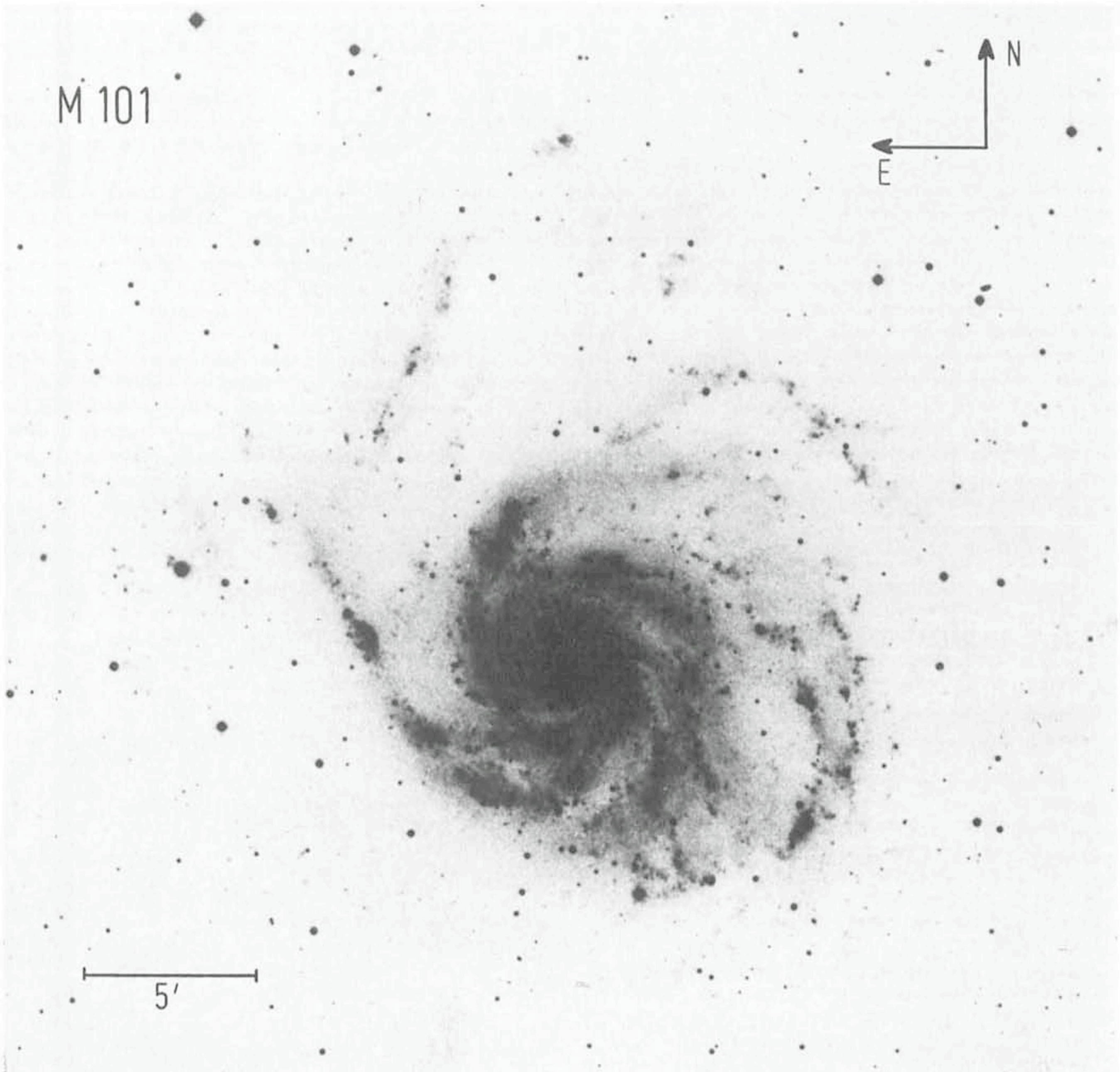

Fig. 1: *Blue photograph of M 101. Note the very large H II complexes in the lower arm extending to the east. (Enlargement from the Palomar Sky Survey print.)*

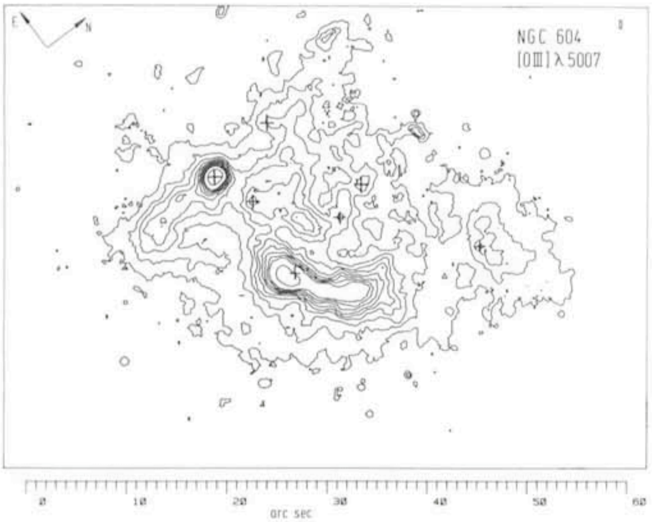

Fig. 2: *Contour map of the core of NGC 604 in the light of nebular [O III] λ5007 emission. Crosses refer to the sources marked in Figure 3.*

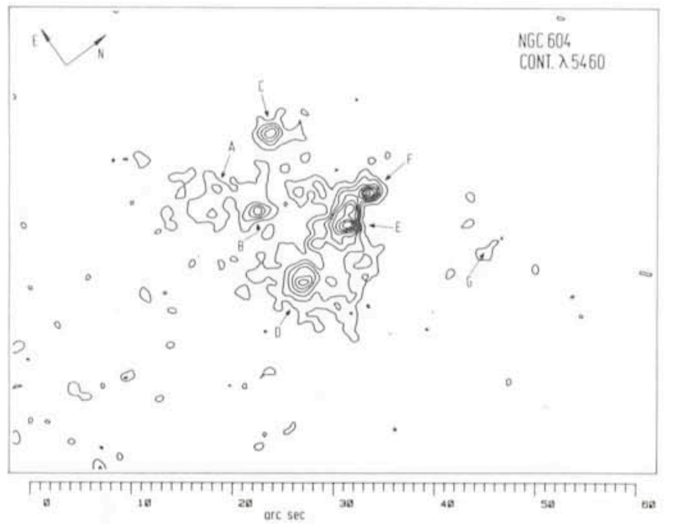

Fig. 3: *Contour map of the core of NGC 604 in a 200 Å wide band centered at 5460 Å (stellar continuum). The brightest knots and the hot spots of Figure 2 are marked by arrows and capital letters.*

results are compared with models of star populations of different ages, mass functions and heavy element abundances.

For most of the H II regions in my programme the data on the nebular emission can be taken from the literature, except for several interesting objects in the southern sky. For the latter, emission line fluxes have been observed with the Image Dissector Scanner at the ESO 1.5 m telescope.

The star light continua, however, had not been given much attention in previous investigations. Due to their faintness they had merely been an insignificant and unwanted background of the order of a few percents of the emission line strengths. Only Searle, in his pioneering spectrophotometry of a large number of H II regions in northern galaxies *(Astrophysical Journal,* **168,** 327, 1971), gave a more detailed description of these continua. Therefore the bulk of my own observations consists of deep spectrograms suitable to search for stellar spectral features and to study the spatial distribution of nebular and stellar light. Long exposure, moderate dispersion image-tube spectrograms have been taken at the ESO 1.5 m and the DSAZ, Calar Alto, Spain 1.2 m telescopes. These spectrograms cover the spectral range from 3500 Å to 7000 Å. In addition, low resolution spectra in the wavelength region 1100 Å to 3400 Å have been obtained with the IUE satellite for the brightest objects. For a number of H II regions the emission line free spectral bands have been observed with the photoelectric scanner attached to the Crossley reflector at the Lick Observatory. These latter observations have been made possible by the generous allocation of observing time by the Staff of the Lick Observatory.

In principle the analysis of the observations is straightforeward. In a first step mean electron temperatures and densities are determined from appropriate emission line ratios. The comparison of theoretical and observed Balmer line ratios yields a reddening correction. The use of a model of the ionization structure then allows us to derive chemical abundances. Of course, corrections are necessary for the unseen stages of ionization, which is very critical in the case of Helium. Finally, the numbers of O type stars needed to ionize the H II regions can be calculated by the use of model atmospheres with proper heavy element abundances. The usual assumption of ionization bound steady state H II regions results in lower limits of these numbers. The spectrophotometry of the stellar continua has to be corrected for the contribution of light from the underlying galaxy, which can be done by properly positioning the "sky" observations. These continua have then to be corrected for scattering and absorption by the dust in the H II regions.

In practice the analysis of the observational data is not that simple. Two serious problems are encountered: The first one is that we do not know which H II region model we have to apply. For obvious reasons the theoretical models available are rather simple compared to even the Orion nebula. Most of them have spheric or cylindric symmetry, are homogenous in density and temperature and assume a pointlike source of ionization. Although some models treat zonal inhomogeneities and can be modified with artificial clumping factors, we do not know to what extend they are reliable, since they have to be tested first on H II regions which offer enough spatial resolution. The second problem is the large scatter of reddening values which are derived by different methods. The visual absorptions obtained from the Balmer line ratios are usually one to two magnitudes less than those required by radio observations. This is certainly a reflection of the very complex mixture of gas, stars and dust within the giant H II regions. Reddening corrections are therefore uncertain and depend on the model used – which in turn one wants to derive from the data.

For example, the giant H II region NGC 5471 in the galaxy M 101 contains about 1000 O stars in a core of about 200 pc diameter, ionizing a gas cloud of 10^7 solar masses and it produces 10^4 times the radio power of the Orion nebula. The question is whether the giant H II regions are just "Super Orion Nebulae", i.e. objects like this well-known galactic H II region enlarged many times. Or are they more likely clusters of hundreds or thousands of Orion-like nebulae, possibly faking us with a rather meaningless average spectrum?

Fortunately there is one giant extragalactic H II region relatively close by. It is the famous 30 Doradus complex in the Large Magellanic Cloud. This object is a very inhomogenous mixture of hot ionized regions, cool, dense neutral clouds and hot stars. The large filaments of ionization fronts and the dust lanes make it look like a tarantula. The extinction law is definitely different from the galactic one, the main distinction being the weakness of the 2200 Å feature. A large fraction of the brightest stars observed in the central cluster of 30 Doradus is of the Wolf-Rayet spectral type and the nature of the strange central object R 136 is still in question (cf. Feitzinger and Schmidt-Kaler, THE MESSENGER No. 19, p. 37, 1979). A closer look at more distant giant H II regions might reveal whether 30 Dor is an exception, or if we can apply our empirical models of 30 Dor to the more remote and generally even larger objects.

4. Some Results on NGC 604

In the following, some results obtained in a study of NGC 604 (the largest H II region in the local group galaxy M 33) are presented. To investigate the morphology of H II regions in nearby galaxies, Rosa, Gaida and Moellenhoff (1981, in preparation) took interference filter photographs at the Cassegrain focus of the 1.2 m telescope of the DSAZ, Spain. As a detector a spectracon tube was used and the images were recorded on Ilford G5 emulsion. The data were digitized using the PDS microdensitometer of the MPIfA, Heidelberg, and reduced with the image processing system of the Landessternwarte Heidelberg. Figures 2 and 3 show the core of NGC 604 in the light of the nebular [O III] λλ4960, 5007 emission and the stellar continuum at 5460 Å, respectively. At the distance of 720 kpc, 4 pc correspond to 1 arcsec on the sky, a scale 13 times smaller than in the case of 30 Doradus. Comparison of the two figures shows a strong anticorrelation between the hot spots in nebular emission and the maxima of the stellar continuum, marked in Figure 2 and 3. Another qualitative result is the large inhomogeneity of the core of NGC 604 at scales of 10 to 50 pc. For comparison the reader is invited to take THE MESSENGER No. 19, Figure 1 at page 37 (cited above) and turn it around 180 degrees. The similarities between the morphology of the cores of NGC 604 and 30 Dor are striking. Note especially the shapes and positions of the bright rims of nebular emission with respect to the cluster of ionizing stars.

Figure 4 shows the low resolution IUE UV spectrograms of NGC 5471 and NGC 604. In an earlier paper *(Astronomy and Astrophysics,* **85,** L21, 1980) it was found that the UV extinction law of NGC 604 seems to be more similar to that of 30 Doradus than to that of the Galaxy, due to the absence of a pronounced 2200 Å feature. The very strong P Cygni profiles of the lines of e.g. C IV and Si IV reported in the paper quoted above indicate

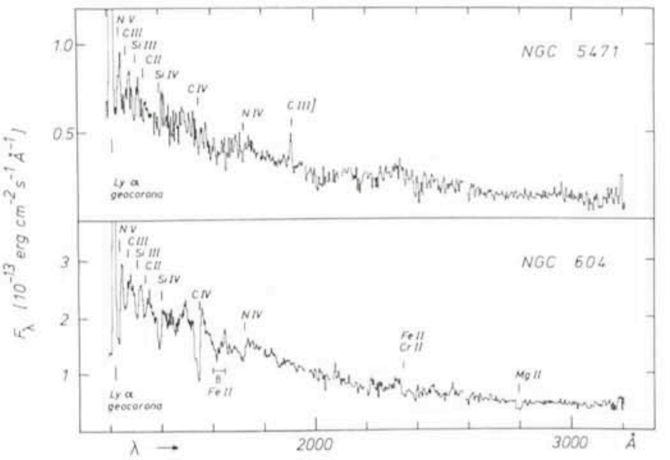

Fig. 4: *Low resolution IUE UV spectrograms of two extragalactic H II regions. Note the strong P Cygni profiles in the tracing of NGC 604.*

very strong mass loss from the observed stars. This led to the suggestion that a number of Wolf-Rayet stars might contribute to the observed UV spectrum (cf. D'Odorico et al., Proceedings of the ESO/ESA Workshop on Dwarf Galaxies, Tarenghi and Kjär edts, p. 103, 1980).

To investigate the nature of the bright knots in NGC 604, D'Odorico and Rosa (ESO preprint 143, 1981) observed the blue visual spectra of knots A,C,D,E and F with the IDS attached to the ESO 3.6 and 1.5 m telescopes. Figure 5 shows the spectrogram of knot E which led to the discovery of Wolf-Rayet stars in NGC 604. The logarithmic intensity scale enables to see the Wolf-Rayet emission bands blueward of He II λ4686 and He I λ5876 together with the 100 times stronger nebular emission lines. These observations imply the presence of about 50 Wolf-Rayet stars in a cluster containing about 50 O type stars responsible for the ionization. This is again similar to the situation found in the core of 30 Doradus. The cause for the high ratio of the number of WR to O type stars is as yet unknown. The ratio found in our galaxy is 10 times less

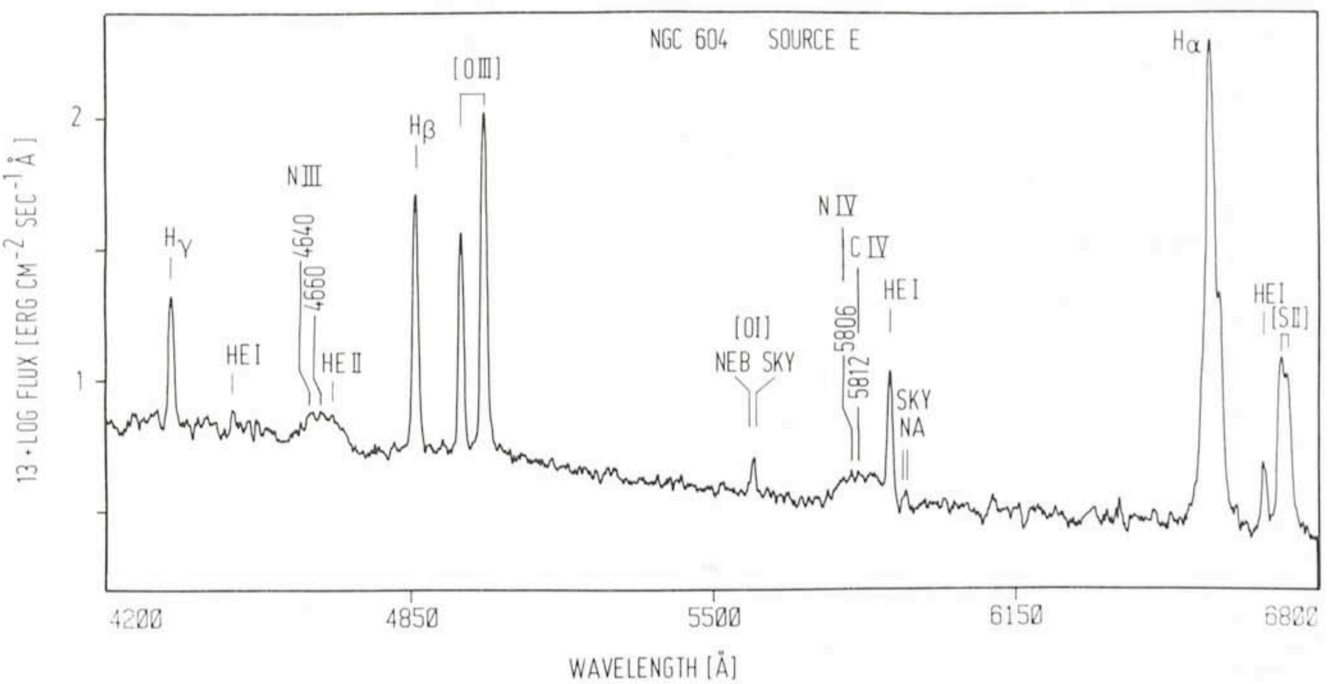

Fig. 5: *IDS spectrogram of knot E (Figure 3) in NGC 604. Emission lines typical of Wolf-Rayet stars are marked with additional wavelength information.*

on the average and may be the equilibrium ratio in the case of continuous star formation. The high ratio found in NGC 604 might then be interpreted as the appearance of a stellar population which has been formed in a single burst about 4×10^6 years ago.

If these high number ratios of Wolf-Rayet stars are found to be common in giant H II regions, they will have large implications on our knowledge of both the WR phenomenon and the star formation and stellar evolution in giant H II regions in external galaxies.

Spinning Asteroids and Photometry: A View of a Modern Topic

H. J. Schober, Institute for Astronomy, Graz, Austria

Introduction

When I first applied for telescope time at ESO in 1976 to carry out photometry of asteroids, I had no idea about the impact of such a programme. As a matter of fact, photometry of asteroids is a method to study those objects in detail for their physical properties such as rotation rates, diameters, surface properties, albedo, geometrical configurations, orientation of rotational axis in space, even masses and densities.

In the meantime quite a number of active asteroid observers have joined and a close cooperation started a few years ago; groups at Torino (F. Scaltriti, V. Zappalà), Brussels (H. Debehogne), Liège (A. and J. Surdej, formerly at ESO), Uppsala (C. I. Lagerkvist) and myself at Graz contributed to the success of the observations of minor planets. Still, the center for collecting all data of asteroids is Tucson-Lunar and Planetary Laboratory, where the TRIAD-file (Tucson Revised Index of Asteroid Data) is maintained, and updated. Though there are many different methods to obtain physical data of asteroids, including infrared, polarimetry or spectrophotometry, I restricted myself to conventional photometry with the main goal to obtain rotation rates, lightcurves and UBV data for an individual asteroid.

Rotation Rates

Times when we considered an asteroid only as a moving pointlike source of light are over. We use ephemerides of course to find and identify objects (you should try to identify a faint asteroid at the beginning of a night on the telescope, if near the Milky Way) and later on, orbital parameters for statistical reasons. If successful in finding the asteroid to be observed (sometimes a few of them in a single night), we follow the object like doing photometry of a variable star, but considering that the object is moving; sometimes fainter stars are included in the diaphragm and those data have to be eliminated, sometimes reidentification in different nights is more difficult.

After successful observations we hopefully obtain an accurate period of rotation of the asteroid body; periods range from only $2^h.27$ (1566 Icarus) and up to $80^h.00$ (182 Elsa). The distribution of rotation periods roughly peaks between 5^h-11^h, but nobody really knows if those periods are generally preferred in the solar system, or if this is caused only by a selection effect.

In Fig. 1 the enormous increase of our knowledge of asteroid rotational data in the last years is shown, leading now to a good data material for statistical analysis. From the histogram of rotation periods we may obtain the following facts:

(a) although the number of observed asteroids has increased by a factor 5 since 1975, still the major part rotates with a $5-11^h$ period.

(b) long periods (slowly spinning objects) show up due to observations carried out carefully or with more patience: 654 Zelinda $31^h.9$ (1975) 393 Lampetia $38^h.7$ and 128 Nemesis $39^h.0$ (1979), 709 Fringilla $52^h.4$ (1979) and finally 182 Elsa with $80^h.00$ (1980), which corresponds to $3^d.33$.

Rotational rates of 1^d or $0^d.5$ are difficult to observe, and there may be quite a large number of asteroids showing rotations much longer, but never observed, as phase and/or geometric effects cover the variability due to rotation only, if amplitudes are small.

Lightcurves

Observed lightcurves mainly represent the geometric configuration – either we get double-mode lightcurves with primary and secondary extrema with amplitudes between 0.00 and 1.50 mag, or single-extremum lightcurves if variations are caused only by albedo spots on the asteroid surfaces – but both effects can be present at the same time. Frequently we remarked that we had to double the value of a period (or got half the value) obtained earlier, because of those effects. But also more complex lightcurves do show up with well defined triple extrema, and we leave it to the reader to imagine an interpretation of such a lightcurve in terms of asteroid configuration.

The form and amplitude of a lightcurve is changing if observed at different aspect configuration, representing the changing triangle asteroid-sun-earth, and due to different views onto the asteroid rotational pole. Under special conditions and with accurate timings of extrema it is possible to obtain the orientation of the axis and even the sense of rotation.

Fig. 1: *The frequency distribution of known rotation periods of asteroids (many of them observed at ESO). Before 1975 the longest rotation period observed was 20 hours – today we reach 80 hours or 3.33 days.*