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Surface photometry of galaxies

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Surface photometry is the study of the distribution of light, and therefore visible matter, in a galaxy. Surface photometry has progressed rapidly in the last several years because of the availability of Charged Coupled Devices (CCD), which have high efficiency and dynamic range, and sophisticated image processing software. Using CCDs on relatively small aperture (1 - 2m) telescopes, features which are as faint as a few percent of the sky background can be easily observed. It is therefore possible to study the morphology of galaxies in different wavelength ranges of the optical region using broad and narrow band filters. The images provide information about the structure of galaxies, the existence of features like rings and bars, distribution of stellar populations and star forming regions, dust and so on. Together with dynamical information obtainable from spectroscopic studies, surface photometry has the potential to provide detailed galaxy models and therefore some understanding of the formation and evolution of galaxies, and the effects produced by galactic interactions.

Elliptical galaxies have isophotes which are usually nearly elliptical in shape. These isophotes are projections in the sky of the 3-dimensional shapes of the galaxies, which are thought to be triaxial ellipsoids in general. When there is an axis of rotational symmetry, the ellipsoids can be prolate or oblate in shape. The isophotes are frequently observed to have ellipticity and major axis position angle varying with distance from the centre. While varying ellipticity is permitted by models with rotational symmetry, a varying position angle is not, and therefore lack of alignment is a signature of triaxiality. The distribution of light in ellipticals is generally very smooth, so that it is possible to isolate faint inhomogeneities. For this purpose, one first fits ellipses to the observed isophotes, taking into account systematic small departures, like boxiness, from perfect elliptical shapes where necessary. A smooth model of the galaxy is then obtained from these fits by interpolation, and substracted from the original image to reveal faint structures. Features can also be found by using 2-colour maps, which are obtained using the B and R images, say. The latter technique is particularly useful in observing the distribution of dust in a galaxy, as the dust tends to be significantly redder than its surroundings. Using observations from the 2.3m Vainu Bappu telescope, recently Mahabal *et al.* (1995) have discovered a dust lane in the radio galaxy 3C270 (NGC 4261), which is situated along the apparent major-axis of the galaxy. The galaxy is known from spectroscopic observations to be a prolate or nearly prolate ellipsoid rotating around the observed major-axis.

The dust lane is believed to be the projection of a disk which has its axis of rotation close to the direction of the observed minor axis, and the direction of the radio jet associated with the galaxy. The small scale disk discovered using Hubble Space Telescope observations by Jaffe *et al.* (1993) is aligned very close to the larger disk, and can be interpreted to be the warped inner part of the latter. The alignment of the disk axis and the radio jet direction is also very interesting, particularly because the rotation of the galaxy is around a completely different direction. The orientation and shape of the lane have important implications for the structure of the galaxy and the origin of the dust, which possibly owes its origin to a past interaction or merger event. Using colour maps, Singh *et. al.* (1995) have discovered a blue ring in an elliptical galaxy, while Pandey *et. al.* (1995) have found a number of examples of thin shells and other features in residual images.

A number of spiral galaxies have spots of prolific star formation, often distributed in the nuclear regions, and are known as star-burst galaxies. The star-formation regions have emission lines because of the ionization produced by massive stars, and their distribution can be studied using narrow band filters centred on the more important emission lines. The star forming complexes can be distributed diffusely, interspersed by dust, as in the case of NGC 2903, or in ring like structures, associated with the Lindbald resonances related to bars. The star burst regions in NGC 2903 have been recently studied in detail by Prabhu et. al. (1995), using broad band images, and maximum entropy image deconvolution to locate the various knots of star formation which appear to be overlapping because of the seeing conditions. The bursts of star formation can affect surrounding regions, leading to further star formation by the compression of clouds, until the ionizing radiation starts to evaporate the clouds before they collapse. The stars in a given burst region can therefore span many generations, significantly affecting the observed spectra (Korchagin *et. al.* (1995)).

The Seyfert galaxy NGC 7172 has a very prominent major-axis dust lane, and has been studied recently by Anupama *et al.* (1995), who have obtained a lower limit on mass of the neutral hydrogen content of the dust from the extinction produced by it. The extinction is obtained by first fitting ellipses to the observed isophotes, and then estimating departures from these in the region covered by dust. The mass estimate obtained in this fashion is a distinct improvement on previous results from radio observations.

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