SURFACE PHOTOMETRY SURVEYS OF GALAXIES WITH SMALL TELESCOPES

S. Djorgovski
Harvard-Smithsonian Center for Astrophysics
60 Garden St.
Cambridge, MA 02138
U.S.A.

ABSTRACT. Surface photometry of relatively bright galaxies is now becoming almost an exclusive province of small telescopes equipped with CCDs. I give a brief review of the scientific possibilities and problems of interest in this field. Small telescopes become tools of observational cosmology: they can provide large amounts of data necessary for the further understanding of fundamental properties of galaxies, clues to their formation, and their interactions with environment.

It is the high quantum efficiency of CCDs that granted to small telescopes this new power. Availability of large amounts of small telescope time makes it possible to do surveys of large numbers of objects, producing homogeneous, good-quality data bases, never available before, and of the quality equal or better than any of the previous, large-telescope photographic work. Small telescopes equipped with CCD cameras exist at KPNO, CTIO, and ESO, and many other places, and thus should be in principle available to anybody with a good scientific project. Appropriate reduction facilities exist at all observatories which operate this kind of equipment, and most major astronomical institutions. Examples of modern surface photometry surveys can be found in papers by Kent (1984, 1985) (105 galaxies), Lauer (1985b) (42 galaxies), and Djorgovski (1985) (262 galaxies). These papers, and references therein, also address the methods of modern surface photometry of galaxies. I will list briefly the possible useful scientific products of galaxy surface photometry. They roughly come in three groups:

First, there are "simple", or catalog-type measurements, such as magnitudes, diameters, colors, mean ellipticities and position angles, characteristic densities (a.k.a. mean surface brightness), and morphological classifications. Everybody who had to do anything in extragalactic astronomy knows how poorly determined such quantities are for all but the few brightest galaxies. The situation is particularly dismal with the magnitudes and diameters of galaxies, which are more often than not just simple eye estimates. There is much space for improvement here: diameters (and consequently standard apertures and

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magnitudes) should be determined in a well-defined, quantitative manner from the surface brightness profiles.

In the second group are the measurements of quantities which can *only* be obtained from surface photometry. Radial density profiles of luminous material: it is now clear that the elliptical galaxies are *not* well described by any of the "standard" formulas. It is not clear how close to exponential are the disks galaxies, either. There is a great variety of surface brightness profile shapes and intensity scales, and quantifying and explaining this variety is the first step toward the better understanding of galaxies in general. Related to this are bulge-to-disk decompositions and measurements of bulge properties; see the paper by Kent (1985). This is necessary for dynamical modelling of disk galaxies, and relates directly to the problems of galaxy formation: are the bulges and the disks coeval? Are the bulges a direct continuation of the family of ellipticals? Ellipticity gradients and isophotal twists in elliptical galaxies carry direct information on galaxy shapes, not deducible in any other way; they may be used to constrain the velocity anisotropy in galaxies. Structure and kinematics of the inner parts of elliptical galaxies and bulges are "fossils" of galaxy formation. Core properties of galaxies are currently not well known. The quantities to be measured include the central surface brightness core radii, and central surface brightness slopes. Derived quantities, such as central luminosity densities, are also of considerable interest. The central surface brightness slopes are directly related to the velocity anisotropy; Lauer (1985a,b) has found that many (most?) ellipticals have non-isothermal cores. The dynamical structure of cores is also important for our understanding of the origin and fueling of nuclear acitivity in galaxies. Color gradients carry direct information on stellar populations and their distribution, and may provide direct constraints for the M/L ratios as functions of radius, and the distributions of dark matter in galaxies.

A quantitative parametrisation of morphological and kinematical properties of galaxies should open the possibility of reliable multi-variate analysis of galaxies. Luminosity (or mass) is certainly one of the principal parameters, but what are the others? The number and identity of such quantities may give us some direct clues on the recipe for making galaxies, and some record of when and how that process happened. We may then be able to design better distance-independent luminosity indicators. For example, there is too much scatter in luminosity - velocity dispersion - metallicity relations for early-type galaxies to be accounted by the error bars alone. Reducing this scatter should lead us to an improvement in the mapping of the Local Supercluster velocity field, and perhaps a better measurement of the far-field Hubble constant.

Finally, there is a third, miscellaneous group of applications, drawing mainly on the *imaging*, and not necessarily on the photometry. One example is a search for subsystems in galaxies, e.g., dust lanes and stellar disks in ellipticals, bars and dynamical resonances in disks, etc.; see the paper by Djorgovski and Ebneter elsewhere in this volume. There is also a possibility of discovering new active and/or unusual nuclei. Repeated observations of a large number of galaxies should

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constrain the supernova rates. Tidal distortions in galaxy pairs provide a way to select a "clean" sample of physical binary galaxies.

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DISCUSSION

Garrison: I'm interested in the different surface photometry results for you E galaxies. Are these CD's and E's mixed together and do you see systematic results? Is there a luminosity dependence?

Djorgovski: There are only a couple of small galaxies in my sample. So far, there is a small indication that the shapes of surface brightness profiles correlate with luminosity.

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