RevMexAA (Serie de Conferencias), **16**, 259–260 (2003)

QUANTIFYING HIGH Z GALAXY SELECTION AND VISIBILITY WITH THE COSMOPACK TOOL

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We have developed COSMOPACK, a set of tools that transform images of real galaxies to depict their appearance at a given redshift as observed with a given telescope and camera. The transformation includes K-corrections, change of observing band, repixelation to the scale of the observing system, convolution by the seeing, and noise from sky, detector, and dark current. We show two applications of COSMOPACK: 1) the visibility of a number of galaxy types, and 2) the recovery of effective radii and effective surface brightness as a function of redshift in the COSMOS survey.

1. INTRODUCTION

At high redshift, low-luminosity and/or low-surface brightness galaxies become harder to detect and eventually fall out of samples as a result of strong observational biases. The redward shift of the galaxy's spectral energy distribution (K correction) and cosmological dimming cause a strong dimming of the surface brightness, as well as a truncation of the galaxy's surface brightness profile. Seeing modifies measured galaxy sizes. Ignoring these effects leads to highly heterogeneous sample properties as a function of redshift and, often, to false suggestions of evolution. These effects may be quantified via simulations of the appearance of galaxy images transported in redshift. Similar simulation studies have been done by Bouwens, Broadhurst, & Silk (1998), Hibbard & Vacca (1997), and others.

2. THE COSMOPACK PACKAGE

Galaxy images are transported in redshift via these steps: 1) the sky level is subtracted; 2) the desired spatial magnification factor is computed, and the image is repixelated; 3) the flux is scaled following i) the luminosity distance, ii) the K correction, iii) the color difference input–output, and iv) the atmosphere–optics–detector efficiency; (3) the image is convolved by the observing system PSF; and 4) Gaussian noise is added to match the desired output image noise from sky, dark current, and detector readout (output skipped if scaled input noise > output image noise).

The code computes K corrections using synthetic SEDs from Poggianti (1997). Linear combinations of SEDs may be input via image masks so that different SEDs may be selected on the basis of, for example, color or position on the galaxy.

COSMOPACK is organized as an IRAF package and is available from the authors.

3. REDSHIFTED IMAGES

To measure visibility of a given galaxy in a given observational set-up, we construct redshifted images using COSMOPACK. An example is given in Figure 1. A given local, compact, star forming galaxy ($R_{\rm e} = 2$ kpc) is shown on the left in its R band, original image, and then its image is simulated at various redshifts, in the R and $K_{\rm s}$ bands. In all cases, the same physical size covered by the image (24 kpc) subtends a smaller angle and a lower number of pixels. Because of its active star formation, this galaxy is detected further out in R than in $K_{\rm s}$.

4. RECOVERING INTRINSIC GALAXY PARAMETERS

We have measured biases in the recovery of galaxy intrinsic parameters such as effective radius and effective surface brightness in distant galaxy samples

An example is given in Figure 2. The galaxy shown in Figure 1 has been redshifted to an array of redshift values from $z = 0.1$ to $z = 2.5$ and observed for 2 hr in the K band on the 4.2 m William Herschel Telescope using the INGRID NIR camera, with $0.7''$ FWHM seeing. On each output image, the magnitude, the effective radius, $r_{\rm e}$, and the mean central surface brightness, $\langle {\rm SB} \rangle_{\rm e}$, measured using SExtractor (Bertin & Arnouts 1996), are plotted against redshift (*points with error bars*). The dashed lines indicate the predictions of cosmology. The solid lines give the predictions of $r_{\rm e}$ and $\langle {\rm SB} \rangle_{\rm e}$ after the seeing

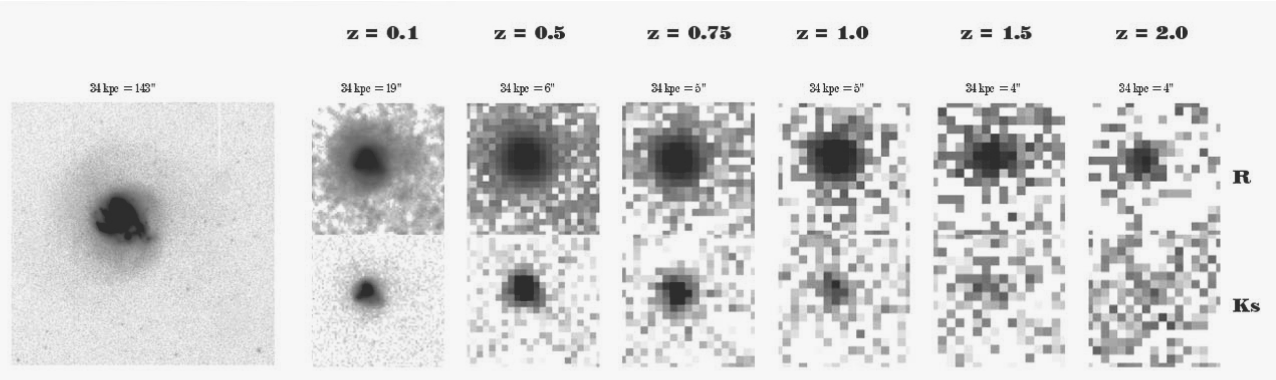

Fig. 1. A sample galaxy image (UCM2325+2318) is shown in R at its original $z = 0.0114$, and then at successively higher z, in R and K_s. Observation simulation corresponds to a 4 m telescope, 2 hr exposure, seeing $0.7''$ FWHM, $h_0 = 0.7$, $\Omega_M = 0.3$, $\Omega_\Lambda = 0.7$.

has been added in quadrature. The figures indicate that this seeing correction gives a reasonable approximation to the sizes of the simulated images. For this compact galaxy, no light is lost buried in the brightness of the K sky. In the adopted observing set-up, SExtractor detects this galaxy out to $z = 1.8$.

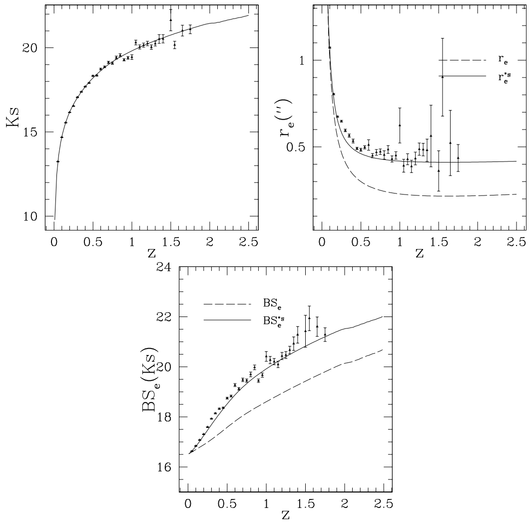

Fig. 2. Surface photometry of a galaxy transported in redshift; parameters measured by SExtractor on the simulated images (see text). Top left: Apparent magnitude. Top right: r_e in arcsec. Bottom: Mean effective surface brightness.

This work was done in preparation for the COSMOS survey. We thank the COSMOS team members for their contributions, especially Rafael Guzmán, Mercedes Prieto, Roser Pelló, Jesús Gallego, Angel Serrano, and Nicolás Cardiel.

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Science with the GTC 10-m Telescope (Granada, España, 5-8 febrero 2002)
Editors: José Miguel Rodríguez Espinosa, Francisco Garzón López & Verónica Melo Martín