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Deconstructing a galaxy: identifying components of M83 with photometric clustering*

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ABSTRACT

Key words: keywords here

1 INTRODUCTION

2 INTRODUCTION

Galaxies are complex systems, comprised of numerous components with an enourmous range of size, mass, density, and composition. These components can be divided into baryonic (stars and their remnants, nebulae, star clusters, nucleus) and non-baryonic (dark matter); cataloging the components and describing the interactions between them is a key step in elucidating the natural history of galaxies. Only in nearby galaxies can individual sub-components be resolved. As observational technology has advanced, the definition of "nearby" has changed and will continue to do so, from Milky Way satellites and Local Group galaxies, to a few Megaparsecs (distance at which stars can be resolved with HST), to XX Mpc (distance at which stars can be resolved with JWST), to the entire observable universe with potential future facilities ().

What is the most efficient way to survey the subcomponents of a nearby galaxy? Here we are discussing components detectable in imaging at ultraviolet through infrared wavelengths, i.e. with effective temperatures in the range XX–XX K. Much cooler or hotter types of objects (molecular gas, accreting compact objects) are better-detected at other wavelengths. Particular stellar types, or star clusters, are often identified with broad-band colour-magnitude diagrams (e.g.). Narrow-band filters can also isolate special stellar types (e.g.) or objects prominent in emission lines such as planetary nebulae or supernova remnants (e.g.). Observations are typically designed with detection of particular classes in mind and sometimes re-used for additional purposes (e.g.). Spectroscopic follow-up is often required to confirm candidates. New observational facilities which provide spatially-resolved spectroscopy (, e.g.) may reduce the need for separate imaging and follow-up steps, but greatly increase the complexity of initial data analysis.

Multi-wavelength surveys are extremely common in studies of unresolved galaxies in the distant universe. While these are often designed to select galaxies or active galactic nuclei with specific properties (e.g.), sometimes they are pure blank-field surveys. Broadband ($R = \Delta\lambda/\lambda < X$) filters are the most common imaging modality, although there have been a few attempts at narrow- or medium-band surveys as well (e.g. **?**), Clustering in colour space can be used to select particular classes of objects from a survey, for example in selecting AGN via mid-infrared colours (e.g.), or high-redshift galaxies via Lyman-break dropouts (e.g.). **give some examples here of sophisticated analysis of colour spaces.**

The purpose of this work is to treat a nearby galaxy as if it were a blank field for surveys, and investigate the usefulness of different photometric colours for identifying sub-components. We make use of the Early Release Science (ERS) observations with the Wide-Field Camera 3 (WFC3) of the nearby spiral galaxy M83 () and in particular the catalog of point sources produced by . We form colours from the photometric measurements in the catalog and apply several clustering techniques to two-colour datasets. In conjunction with published catalogs of galaxy components, we identify the optimum parameters for clustering such a photometric dataset, and the best choices of filter.

3 DATA

4 DATA

The dataset used for this study is the Wide-Field Camera-3 Early Release Science (ERS) observations of the nearby spiral galaxy Messier 83 (M83). M83 is a grand-design spiral of type SAB, located at a distance of 4.66 Mpc (Tully et al. 2013) and the largest member of the M83 subgroup of the nearby Centaurus group of galaxies (Tully 2015). The galaxy's apparent radius of ~ 12 arcmin () is reasonably well-matched to the camera's field of view (XX true? XX) **And here we note some other interesting things about M83.**

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Table 1.

Filter	Name	Exposure time
F225W	Wide UV	1800 s
F336W	U-band	1890 s
F438W	B-band	1180 s
F487N	Hβ	2700 s
F555W	V-band, South field	1203 s
F814W	I-band	1203 s

The objective of the ERS observations as a whole was to probe star formation in galaxies. The observations of M83 were made in broad- and narrow-band filters in order to characterize both stellar and nebular properties. They cover a 3.6×3.6 kpc^2 region in the northern portion of the galaxy, including the nucleus, a portion of a spiral arm and an interarm region. The spatial resolution of the images is $0\farcs0396$ arcsec pixel^{-1}, corresponding to a linear scale of XX pc pixel^{-1} at the 4.66 Mpc distance. A complete description of the observations and data processing is given by Chandar et al. (2010); our work here uses the observations in the UVIS channel, listed in Table 1. A number of previous studies have used the ERS M83 dataset for various purposes. These include studies of star clusters (Chandar et al. 2010; Wofford et al. 2011; Whitmore et al. 2011; Bastian et al. 2011, 2012; Fouesneau et al. 2012; Silva-Villa et al. 2013; Andrews et al. 2014; Chandar et al. 2014; Adamo et al. 2015; Ryon et al. 2015; Hollyhead et al. 2015; Sun et al. 2016), H II regions (Liu et al. 2013), supernova remnants and the interstellar medium (Dopita et al. 2010; Hong et al. 2011; Blair et al. 2014, 2015), resolved stars (Kim et al. 2012; Williams et al. 2015), and a super-Eddington off-nuclear black hole (Soria et al. 2014).

We analyze the catalog produced by Chandar et al. (2010) and made available via **REF**. The objects in this catalog were detected on a 'white-light' image produced by a weighted combination of the $UBVI$ images. Photometry in 0.5- and 3-pixel radius apertures at the positions of the detected sources was performed on the broad- and narrow-band images and tabulated in the Vega magnitude system. We apply the correction to the F657N magnitude zeropoint (from 20.72 to 22.35) noted in the header of the catalog. Chandar et al. (2010) discussed aperture corrections for this catalog, but since we are primarily concerned with colours, we omit any aperture corrections. The catalog contains about 68000 objects which are expected to include individual stars, star clusters, supernova remnants, H*ii* regions, planetary nebulae, stellar blends, and background galaxies. Completeness and reliability of the catalog are not discussed by Chandar et al. (2010), but a visual inspection of the the detected sources on the white-light image suggests that XX objects are flagged in the catalog as being problematic and we remove them from our analysis.

Table 2 and Figure 1 characterize the catalog in terms of measurements in individual filters. Not all objects are detected in all filters; Table 2 gives the number of objects for which photometry is reported in a given filter, the number for which reported magnitude uncertainty is 0.2 mag or less, and the aperture magnitude at which the median magnitude uncertainty is 0.2 mag. Figure 1 shows the distributions of magnitudes and uncertainties in the individual filters.

Table 2.

Filter	$N_{\rm obj}$	$N_{\rm good}$	$m_{\rm good}$	$N_{\rm X-555}$
F225W	N	N	m	N
F336W	N	N	m	N
F373N	N	N	m	N
F438W	N	N	m	N
F487N	N	N	m	N
F502N	N	N	m	N
F555W	N	N	m	N
F657N	N	N	m	N
F673N	N	N	m	N
F814W	N	N	m	N

Our analysis in this paper is primarily concerned with colours, rather than luminosities. Uncertainties in colours are computed as the quadrature sum of the relevant magnitudes. Observations in 10 bands allow the generation of 45 different colours, but not all of these colours are likely to be useful in characterizing components of the galaxy. As the F555W band has the most individual detections, we initially compute colours relative to this band. The last column of Table 2 gives the number of objects for which a 'good' colour (uncertainty < 0.2 mag) is available.

5 ANALYSIS

Outline for analysis

(i) description of technique(s)
(ii) experiments with how to apply the technique
(iii) final parameters used

6 RESULTS

Well, what did you learn?

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Figure 1. Distribution of magnitudes and uncertainties for objects in the Chandar et al. (2010) M83 ERS catalog.

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