Abstract. The Reference Catalog of Spectral Energy Distributions of 800,000 galaxies (RCSED) includes the results of uniform re-processing of 800,000 SDSS DR7 galaxies at redshifts $0.007 < z < 0.6$ complemented with ultraviolet-to-infrared photometric data from GALEX, SDSS, and UKIDSS. The key difference between RCSED and existing databases of galaxy properties (NED, HyperLeda, part of SIMBAD) is that rather than providing a compilation of literature data, we perform homogeneous data analysis of spectral and photometric data using our own tools and publish derived physical properties of galaxies along with re-calibrated spectra and photometry and their best-fitting models. Here we present the 2nd release of our catalog, RCSEDv2 where we substantially expanded the spectral dataset to 4 million objects by including spectral data analysis for 10 large spectroscopic surveys (SDSS, SDSS/eBOSS, LAMOST, Hectospec, CfA redshift surveys, 2dFGRS, 6dFGS, DEEP2, WiggleZ). The photometric part has also been expanded by including DESI Legacy Survey, DES, UHS, ESO Public Surveys, and WISE in addition to GALEX, SDSS, and UKIDSS used in the original RCSED. This makes RCSEDv2 the largest database of galaxy properties and homogeneously processed spectral and photometric data up-to-date and creates a foundation for the analysis of future large-scale spectral surveys DESI and 4MOST.

1. Motivation and Scope

Statistical studies of galaxy formation and evolution require knowledge of galaxy properties going beyond simple redshift measurements. Millions of optical spectra became available over the past 2 decades as a result of wide-field spectroscopic surveys carried out at different observatories all over the world. In 2010–2017 we undertook a major effort to re-process 800,000 galaxy spectra from the legacy spectroscopic sample of SDSS. We complemented spectra with aperture and integrated photometry in the
ultraviolet wavelengths from Galaxy Evolution eXplorer (Martin et al. 2005), optical domain from SDSS, and 4 near-infrared bands from UKIDSS (Lawrence et al. 2007) converted into rest-frame using k-corrections (Chilingarian et al. 2010) to allow one to compare photometric measurements for galaxies at different redshifts. This Reference Catalog of Spectral Energy Distributions (RCSED) of galaxies (Chilingarian et al. 2017) has already been used for a number of successful research projects. We decided to substantially expand the catalog by including virtually all publicly available spectral galaxy surveys and data from new deep wide-field imaging surveys.

2. RCSEDv2: Data and Analysis

Spectroscopic datasets included in the RCSEDv2 comprise: SDSS DR16 galaxy and QSO spectra (Ahumada et al. 2020), 2dF Galaxy Redshift Survey (Colless et al. 2001), 6dF Galaxy Survey (Jones et al. 2004), DEEP2/3 surveys (Newman et al. 2013), WiggleZ (Parkinson et al. 2012), LAMOST DR7, public spectra from the Hectospec spectrograph, and several CfA redshift surveys from the 60-inch telescope at Fred Lawrence Whipple Observatory, the most notable being a recently released public archive of FAST (Mink et al. 2021). The two latter datasets are collections of uniformly reduced pointed observations from the corresponding data archives, e.g. these are not survey datasets even though some subsets of them are indeed galaxy surveys with specific selection functions. All the remaining datasets are galaxy surveys that is datasets where the target selection functions are well defined. Currently, we have a total of 4.6 million galaxy spectra included in RCSEDv2. For every spectrum, we provide aperture-matched UV-to-IR fluxes from several wide-field imaging surveys (GALEX, SDSS, Legacy Surveys, DES, UKIDSS, UHS, ESO Public Surveys, WISE). We also publish extinction- and k-corrected integrated fluxes for most galaxies in the RCSEDv2 sample.

We use the NBURSTS full spectrum fitting technique (Chilingarian et al. 2007a, b) with several grids of stellar population models and, for a subset of spectra where we had available UV and NIR photometric data, we fitted broadband spectral energy distributions simultaneously with spectra using the NBURSTS+PHOT code (Chilingarian & Katkov 2012). For every data source we created a pre-processing routine, which converts the original data into the same format, applies flux calibration and correction for telluric absorption (if needed), prepares a map of wavelength-dependent spectral resolution for each spectrum and finally allows us to run our spectral fitting code. The spectrum fitting returns stellar (absorption-line) and gas (emission-line) kinematics and a star formation history in a parametric form, typically age, metallicity, and α-enhancement of stellar population. We use several grids of stellar population models and include the corresponding parameters of the star formation history in RCSEDv2 for every model grid.

3. Technical Solutions and Data Access

We use PostgreSQL database engine with PGSPHERE (Chilingarian et al. 2004) as a back-end solution. The intermediate layer for Virtual Observatory access protocols is provided by GaVO DaCHS (Demleitner et al. 2014). The intermediate-layer uses DJANGO for database interaction. The front-end is powered by several modern JAVASCRIPT frameworks and also uses ALADIN-LITE Sky Atlas (Boch & Fernique 2014).
Figure 1. Redshift distributions of RCSEDv2 galaxies originating from different spectroscopic datasets. The y axis scale is logarithmic.

Figure 2. A screenshot of an RCSEDv2 web-page for NGC 60 with a summary of its properties and the first available spectrum with the parameters derived from it. Red markers over a galaxy image display the positions of available spectra.
4. Research Highlights and Perspectives

Using RCSED (i) we discovered the universal optical-UV color-color-magnitude relation of galaxies (Chilingarian & Zolotukhin 2012); (ii) we identified over 70% of known compact elliptical galaxies (Chilingarian & Zolotukhin 2015); (iii) we found a population of intermediate-mass black holes which power active galactic nuclei (Chilingarian et al. 2018); (iv) we identified progenitors of present-day ultra-diffuse galaxies as low-mass spatially extended post-starburst galaxies in clusters (Grishin et al. 2021). With RCSEDv2, a new version of our dataset, we have already found young analogs of compact elliptical galaxies, substantially expanded a sample of intermediate-mass black holes, and found many active galactic nuclei in rare giant low-surface brightness galaxies (Saburova et al. 2021).

Numerous interesting research results in the field of galaxy formation and evolution and in the studies of the large-scale structure of the Universe are expected to be spawned by the analysis of the largest homogeneously processed extragalactic dataset provided by RCSEDv2. We expect to use the infrastructure and data processing and analysis approaches to the data which will be delivered by the next-generation large spectroscopic surveys DESI and 4MOST.

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