Abstract

"Patience is bitter, but its fruit is sweet."

– Aristotle

Dwarf galaxies significantly populate the Universe. However, the evolutionary connection between the diverse morphology of the dwarf galaxy population is not yet fully understood[1]. Moreover, there are discrepancies between the observed properties of dwarf galaxies and the predictions derived from cosmological models. To solve this puzzle, it is crucial to target young and actively growing galaxies in the rest-frame far-ultraviolet (FUV, $\lambda \sim$1500 Å) – tracing star-formation activity over the past 100 million year timescales. The outer regions of these actively growing galaxies are particularly important as cosmic gas accretion is likely to have driven their evolution. In this light, the *HST* already has and the *JWST* now is pushing detailed dwarf galaxy studies to very high redshifts (starting with the *HST's* F435W filter, which samples rest-frame 1500 Å at $z \gtrsim 1.4$ or so). However, the intermediate redshift dwarfs remain elusive in the FUV due to *GALEX*'s low resolving power beyond $z > 0.05$ or so[2].

The goal of this thesis is to gain a better understanding of the mass assembly and evolution of star-forming dwarf disk galaxies that lie beyond the Local Universe (>100 Mpc). We primarily study a sample of star-forming dwarf galaxies called Blue Compact Dwarf galaxies (BCDs) at redshifts $0.1 \leq z \leq 0.24$ ($\sim$ 460 - 1200 Mpc) which corresponds to look-back times of 1.3 - 2.8 billion years in standard cosmology. BCDs are a class of low-luminosity ($M_K > -21$ mag)[3], metal-poor ($\frac{1}{50} \leq Z/Z_{\odot} \leq \frac{1}{2}$)[4] galaxies with centrally concentrated, active star formation (10^{-3} - 10^{2} $M_{\odot}$ yr^{-1})[5]. The sample lies in

the *GOODS-South* field for which we have recently obtained deep ultraviolet (UV) observations with the *Ultra-Violet Imaging Telescope (UVIT)*[6] onboard India's first multi-wavelength space telescope - *AstroSat*[7]. With a factor of ∼3 or more better spatial resolution than *GALEX* as measured, *AstroSat-UVIT*[6, 7] allows us to bridge the gap in understanding of dwarf galaxies between those in the Local Universe and those at higher redshifts.

I begin the thesis by discussing briefly the general understanding of galaxies and the diversified nature of dwarf galaxy population and their evolution. BCDs are often considered as a bridging phase among other dwarf morphologies[1, 8], and have properties that mimic high redshift star-forming galaxies like low metallicities and high gas fractions. I discuss the current understanding of BCDs and their role in shedding light on the puzzle of galaxy formation and evolution.

In the ΛCDM paradigm, gas accretion from the surrounding environment and subsequent star formation are important aspects of galaxy growth[9–12]. In fact, there is direct evidence for gas accretion in some local galaxies including BCDs and starburst dwarfs[13–15]. This process manifests itself as what is known as an extended ultraviolet (XUV) disk[16, 17] which exhibits recent and spatially extended star formation in the outskirts of galaxies. XUV disks demonstrate the natural disk-building process in a galaxy[18]. In *Chapter 2* of the thesis, I present and discuss the analysis of the multi-wavelength morphologies of our BCDs based on *UVIT*[6] and *HST* imaging observations. We find that the largest FUV counterparts are spatially extended than their optical ones by a factor of ∼two or more. Their modelled radial light profiles also reveal that the slopes of the FUV light profile are shallower than those at longer wavelengths. These observations indicate the presence of XUV disks in these BCDs and imply an ongoing assembly of the outer stellar disk over the past 100 million years or more. We confirm this using the existing XUV disk criteria applied to local galaxies[18]. This is for the first time that we are witnessing this phenomenon in distant BCDs.

Local XUV disks are usually characterised by bright star-forming clumps in their outskirts. Now, a clumpy and irregular disk implies gravitational instabilities that lead to star formation. Past observations have revealed that galaxy disks become increasingly clumpy at higher redshifts and inevitably play an important role in the overall disk assembly. At the same time, a clumpy morphology also serves as an indicator of gas accretion[10, 19]. With our deep, high-resolution *UVIT*[6] observations, we are able to detect large FUV clumps in the outskirts of our BCD sample, which otherwise is not possible with *GALEX* observations. We find that the clumps are massive, of the order 10^6 $M_{\odot}$ (~ 1 % of total galaxy masses). High-resolution *HST* observations also reveal their inner clumpy morphology, a common feature observed in other BCDs as well[3, 20]. In *Chapter 3*, I discuss the robust methods to detect the outer clumps using automated tools like *Source Extractor*[21] as well as a manual approach. A clumpy and irregular disk also implies that disk torques may drive radially inward motion. This thereby helps in the build-up of the central stellar concentration like bulges and spheroids in massive galaxies [22–25]. In a simple dark matter halo set-up, we estimate the timescales for clump migration and clump-driven disk evolution due to dynamical friction[26]. We find that the clumps migrate inward at an average rate exceeding 10^6 $M_{\odot}\mathrm{Gyr}^{-1}$. The whole outer disk would however require several Hubble times and likely fade away into extended old stellar disks as seen in local BCDs[27].

Local dwarf galaxies have exhibited star formation to very low gas surface densities in their outer parts, albeit inefficiently and without any apparent threshold[28]. Ongoing star formation in such low-density and metal-poor environments serve as excellent opportunities to test the models of star formation[29] and to look for a true threshold or mechanism of inefficient conversion of gas into stars. In *Chapter 4*, I present the star-formation properties of the BCDs focusing on their XUV regions. We are able to measure the outer star-formation rate surface densities (SFRDs), based on the FUV fluxes, down to 10^{-5} - 10^{-6} $\mathrm{M}_{\odot}\mathrm{yr}^{-1}\mathrm{kpc}^{-2}$. Such values would translate to gas surface densities of the order $\sim$1 $\mathrm{M}_{\odot}\mathrm{pc}^{-2}$ or less as per the Kennicutt-Schmidt law in XUV disks[30, 31]. We study the broadband UV colours by performing stellar population modelling using the STARBURST99 code[32]. The modelled stellar population ages come out to be a few tens to a few hundred million years old; consistent with previous observations in outer parts of XUV disks[33]. These findings demand a probe into how the outer gas is distributed in these systems and whether such low levels of recent star formation is continuously fed by accreting gas from the intergalactic medium.

Previous observations of XUV disks in the nearby Universe indicate that such a scenario can be traced down to dwarf galaxies at present times[2, 18]. However, XUV disk in dwarf galaxies is not extensively discussed in the literature. XUV disk is an indication of the natural inside-out assembly of galaxy disks but local dwarfs are seen to grow in a contrary manner. Our results from intermediate redshift BCDs in the *GOODS-South* field motivate us to probe if the XUV phase is a common aspect in other BCDs as well and how it influences their disk assembly process. For this, we have proposed FUV observation time for a sample of nearby BCDs under *AstroSat's* Long Term Key Proposal. In *Chapter 5,* I describe our observations obtained so far and present the preliminary results. Our preliminary findings indicate that the incidence of XUV disks in nearby BCDs is lower than what we find in the case of intermediate redshift BCDs. It is important to note that, the BCDs presented here do not form a complete sample. High-resolution UV observations of a larger sample of BCDs will be able to provide further insight into this.

I finally summarize and conclude the thesis with *Chapter 6*, highlighting the implications of our work in the light of galaxy mass assembly and lay down future prospects of the work.