The Shell region in the North-Eastern Small Magellanic Cloud: Star formation history & Kinematics using UVIT/AstroSat & Gaia

Sipra Hota[1,*], Annapurni Subramaniam [1], Dhanush S. R.[1], Maria-Rosa Cioni [2]

[1] *Indian Institute of Astrophysics, Bangalore, India*
[2] *Leibniz-Institut für Astrophysik Potsdam (AIP),Germany*

*sipra.hota@iiap.res.in

Introduction

- The Small Magellanic Cloud (SMC) is one of the nearest gas-rich dwarf satellite galaxy of the Milky Way (MW) at a distance of 60 kpc. Its' evolution is affected by the interaction with the Large Magellanic Cloud (LMC) and/or with the MW.
- The North-East outer disk of the SMC, known as the **Shell region**, is a tidally affected region and likely to harbor clues to recent interactions.
- **UV-study along with kinematics** of this region is important to reveal the features of past interactions.

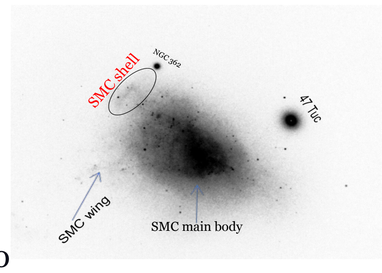

Figure 1: Small Magellanic Cloud (*F. Niederhofer et al.2021*)

UVIT & Gaia Data

- Ultra Violet Imaging Telescope (UVIT)
- Filter : F148W (λ = 148 nm)
- Science ready image : **CCDLAB**
- Photometry : IRAF tool
- Photometric error: upto 0.2 mag
- Cross-matched with Gaia EDR3 data
- Cross match radius = 1"
- The MW decontamination : ***3 sigma cut-off to parallax, μ_α & μ_δ***

Table: Details of UVIT observed fields

Observed Field	Exp time (Sec)	RA (Deg)	Dec (Deg)
Field 1	2406.4	14.55	-70.76
Field 2	2405.7	14.94	-71.12
Field 3	2373.2	15.37	-70.48
Field 4	2371.2	16.16	-71.22
Field 5	2366.2	17.05	-70.96
Field 6	2208.1	17.87	-70.66
Field 7	1533.6	18.26	-71.03
Field 8	2373.6	18.79	-71.36
Field 9	2375.1	19.25	-71.73
Field 10	1903.6	17.22	-71.27
Field 11	1902.5	17.22	-71.41

FUV catalog

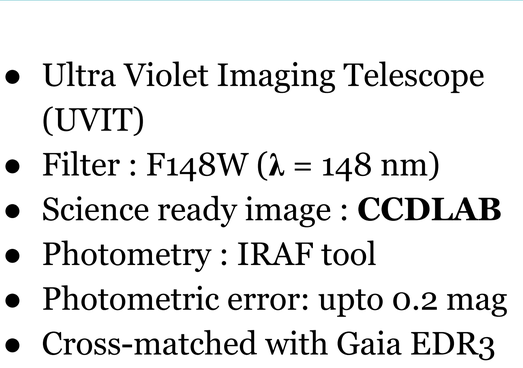

Figure 2: FUV catalogue of the SMC Shell.

- # of Far-UV sources ~ 1.5×10^4.
- Two morphological structures.
- Martínez-Delgado et al. 2019 detected these features using the SMASH data.

Color-Magnitude Diagram

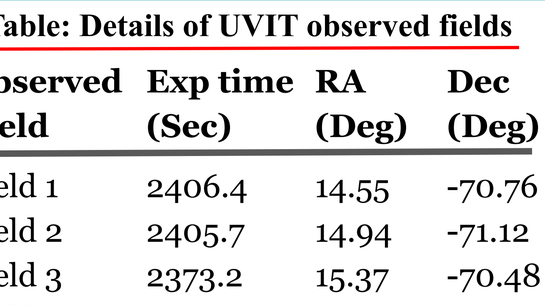

Figure 3: FUV - optical CMD.

- Padova-PARSEC isochrones
- Inputs:
  1. m-M = 18.96 mag
  2. Z= 0.002
  3. E (B-V) = 0.05 mag
- Younger stars ~ **7 Myr**
- Majority SF ~ **300-150 Myr ago**
- **Recent enhanced SF at 70 Myr**

Surface density of the FUV stars

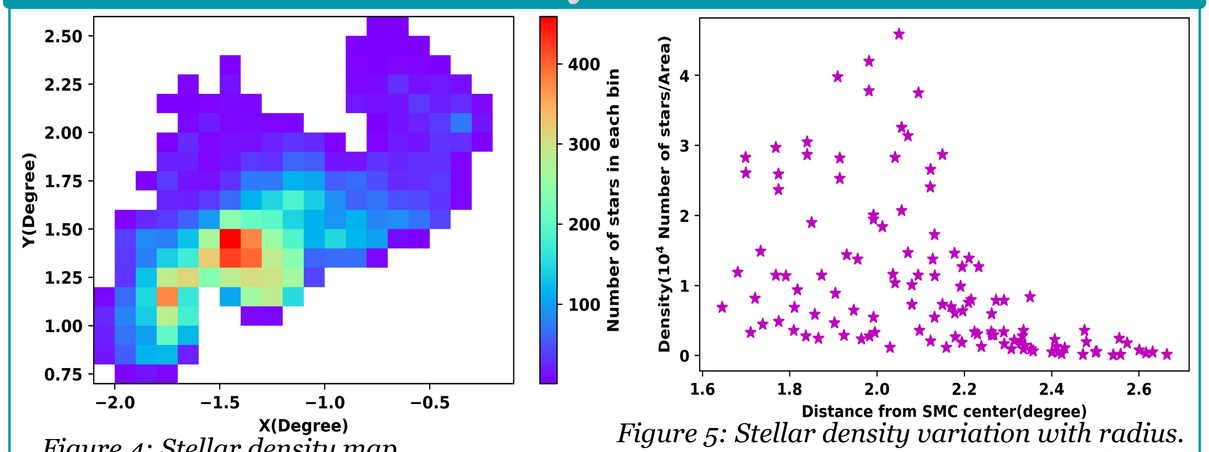

Figure 4: Stellar density map.

Figure 5: Stellar density variation with radius.

- Bin size : 0.1° in x & y direction.
- FUV stellar density decreases radially outwards.
- A few dense regions between 1.9° to 2.2°.
- Nearly uniform gradient between 1.6° to 2.2°.
- Drastic drop in FUV stellar density beyond 2.2° - Edge of the young north- eastern SMC.

Conclusion

We detected the edge of the young component of the SMC in the NE part at 2.2°. The shell region experienced a major star formation during 300 - 150 Myr. After a short break, the region experienced a SF episode around 70 Myr and a scattered episode at 7 Myr. The high mass stars in the region show a relatively low velocity dispersion, compared to the low mass stars. The region with the arc like feature appears to relatively less disturbed when compared to region hosting the shell region. Thus we present a comprehensive study of the young stars in the Shell region of the SMC.

Spatial distribution of Proper Motion

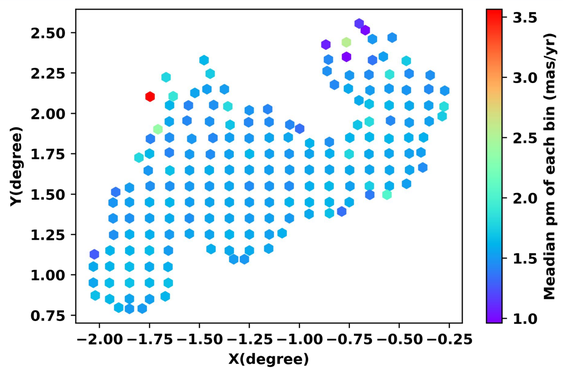

Figure 6: Spatial distribution of the median pm.

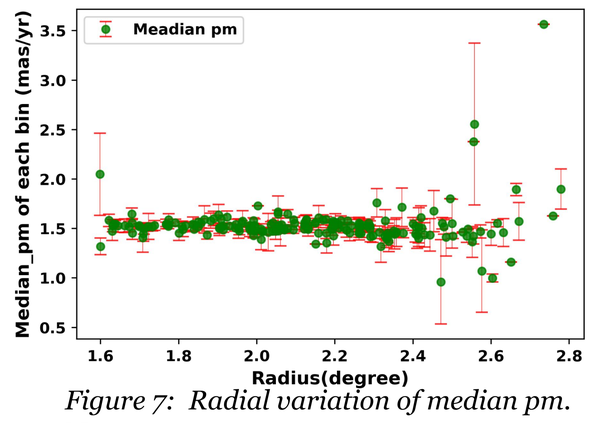

Figure 7: Radial variation of median pm.

- No gradient in pm within the shell region is noticed.
- Majority of the bins show similar pm as the SMC main body.
- Beyond 2.4° from the SMC centre, a scatter in median pm is noted.
- Residual pm = median value of pm of each bin - pm of the SMC at center
- Western side appears to be more kinematically stable than the western side.

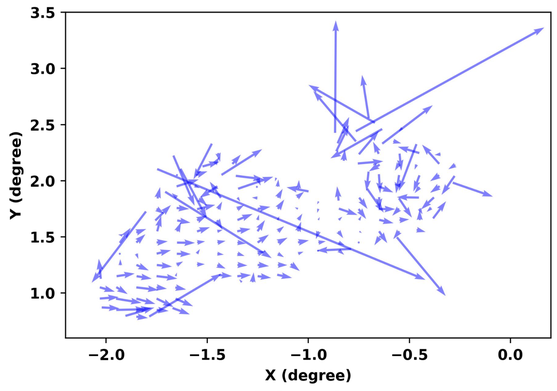

Figure 8: Spatial distribution of the residual pm.

Arm-like structure

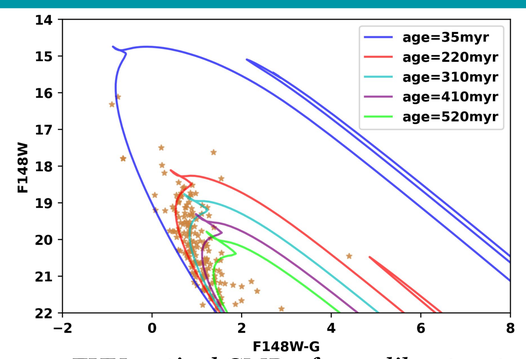

Figure 9:FUV-optical CMD of arm-like structure.

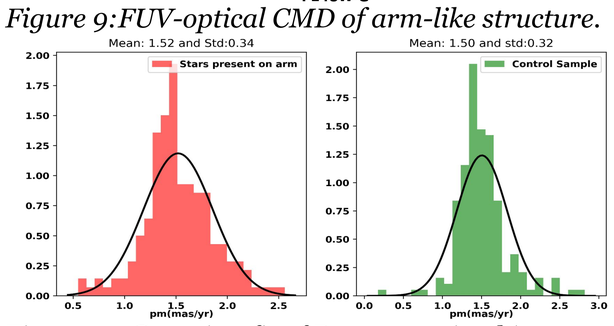

Figure 10:Gaussian fit of Proper motion histogram.

- Increased star formation **: 310-220 Myr ago**
- Kinematically similar to stars in nearby region
- Shows episodic star formation

Arc-like structure

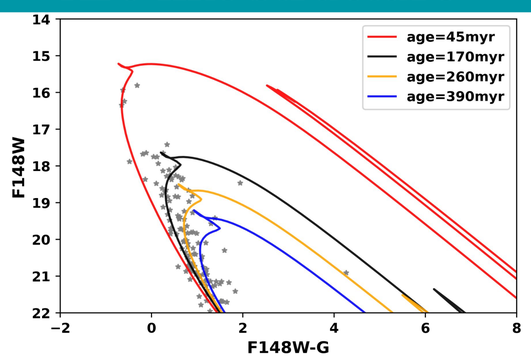

Figure 11:FUV-optical CMD of arc-like structure.

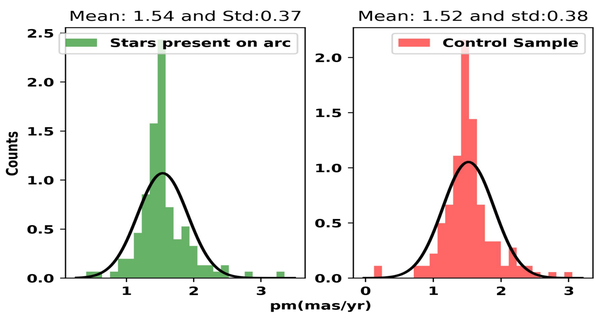

Figure 12:Gaussian fit of Proper motion histogram.

- Increased Star formation(SF) **: 260-170 Myr ago**
- Kinematically similar to stars in nearby region
- Likely to be a stellar over density

Age of Star Formation

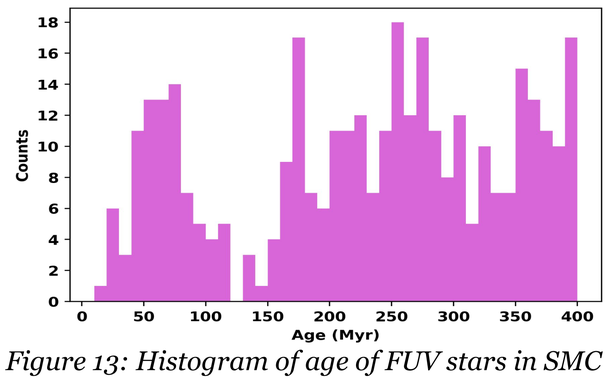

Figure 13: Histogram of age of FUV stars in SMC shell region.

- Peak of star formation at ~ 250 Myr
- Indicating formation of this region due to LMC-SMC interaction
- SF happened ~ 350 Myr then reduced drastically and again sudden increment ~ 250 Myr and Latest SF~ 70 Myr

Different types of Population

1.MS bright star: MS branch, brighter than 17.4 mag
V_{dis} = *39 km/s*

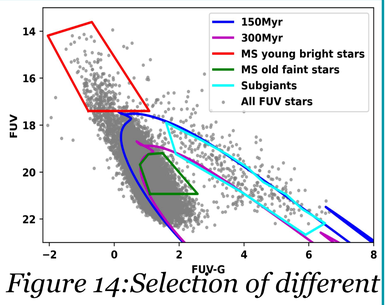

Figure 14:Selection of different stellar populations.

2.MS faint star: MS branch, 19 <mag< 21
V_{dis} = *79 km/s*

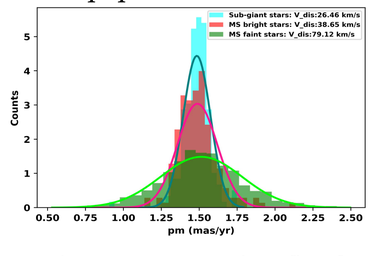

Figure 15:Gaussian fit of histogram pm of different stellar populations.

3.Sub-giants: Fainter than 19 mag and between 150-300 Myr
V_{dis} = *26 km/s*

References:

- Gaia Collaboration et al. 2018
- D.Martínez-Delgado et al.2019
- Haschke et al.2011
- Niederhofer et al. 2021
- Postma et al. 2011