The Structure & Dynamics of the LMC's Bar In an Era of Big Data and Resolved Stellar Populations

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A main science objective of the Rubin Observatory is to understand the Milky Way structure and formation through its vast datasets of resolved stellar populations. A key component of this is to understand the structure and dynamics of the Milky Way satellites. We demonstrate this opportunity space by attempting a precise structural analysis of the LMC's Bar using resolved stellar populations in Gaia DR3. We compare our measurements with numerical simulations and derive insights into the LMC-SMC interaction history.

1) The LMC's Strange Bar

- The LMC's Bar has properties typically not seen in galactic bars. It is offset from the disk center (Fig 1), is tilted out of the disk plane and is not evident in gas.
- SMC's interactions with the LMC might be responsible.

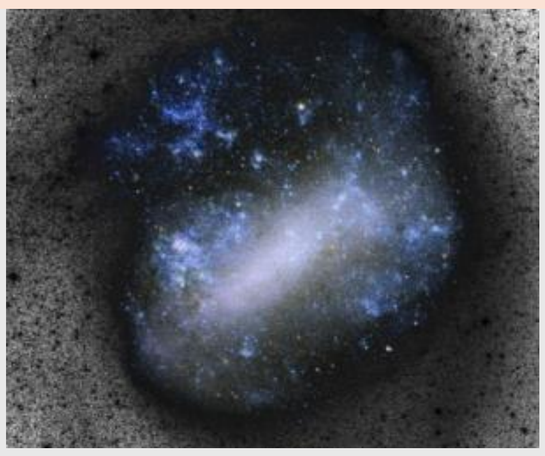


Fig 1: The LMC's bar in optical [1]

2) Why Measure the LMC's Bar ?

Precise measurements of the LMC's bar is important for understanding the origin of its strange properties, placing the LMC in the context with other barred spiral galaxies, and understanding the role of bars in the evolution of small galaxies.

3) Stellar Crowding is a Major Challenge

- Gaia DR3 offers a golden opportunity to study the LMC's bar in detail through its vast astrometric and kinematics datasets.
- We use red clump stars, since they are a good tracer of the LMC's bar and enable comparisons with N-body simulations.
- However, in the era of big datasets like Gaia, stellar crowding is a major challenge in the inference of galaxy structure (Fig 2).

4) A Novel Solution to Crowding Induced Incompleteness Using the Gaia BP-RP Color Excess

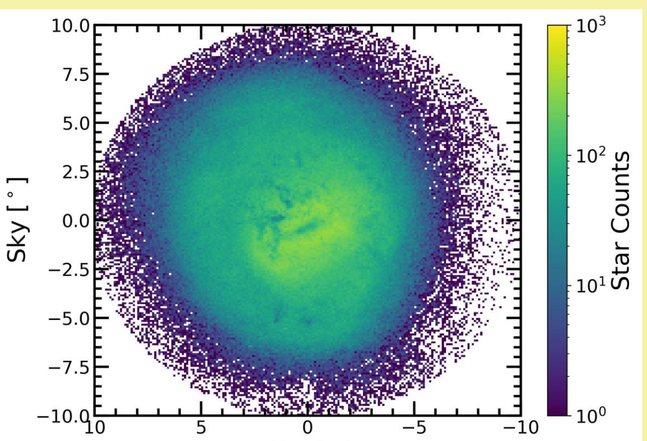


Fig 2: The LMC disk in Gaia DR3 red clump. Central region is very crowded and incomplete.

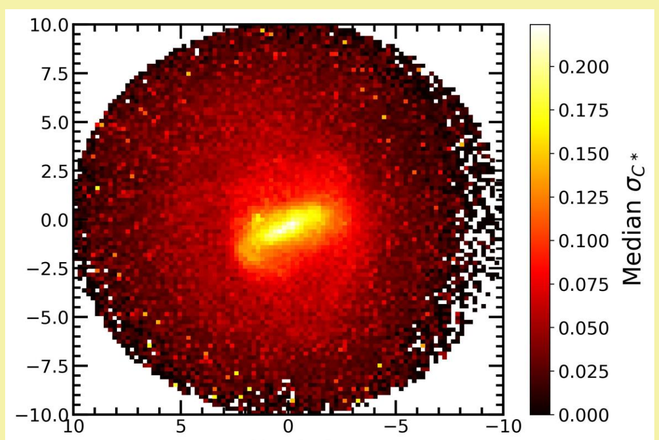


Fig 3: Spread in Gaia BP-RP color excess probes crowding and can be used to correct incompleteness.

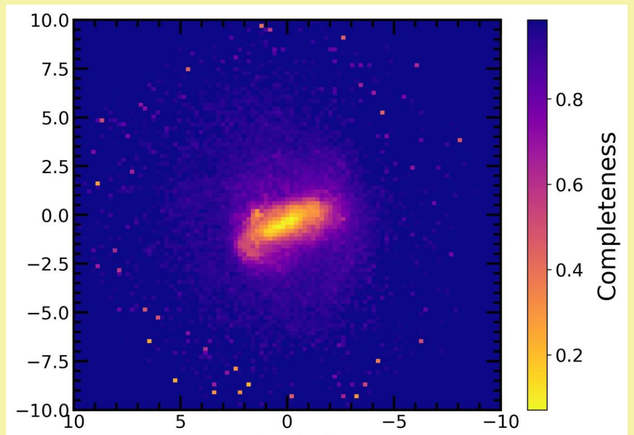


Fig 4: A completeness map for the LMC disk derived from the spread in color excess.

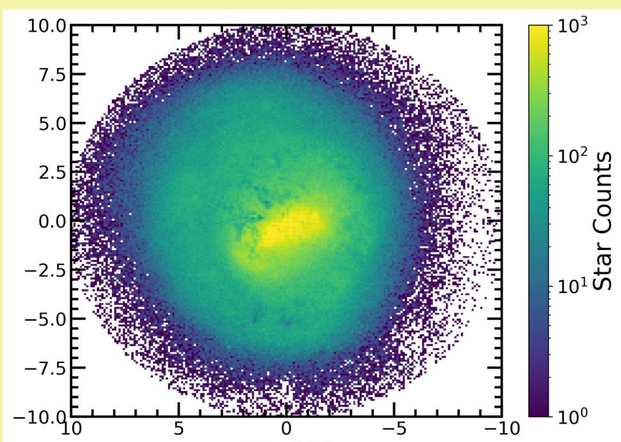


Fig 5: Completeness corrected LMC disk. The central features like the bar become prominent.

5) Main Result

We measure the LMC bar properties like its radius and strength using the bi-symmetric component of the Fourier transform of the LMC's disk. We find that the LMC's bar is consistent with standard scaling relations like the bar radius - strength relation (Fig 6).

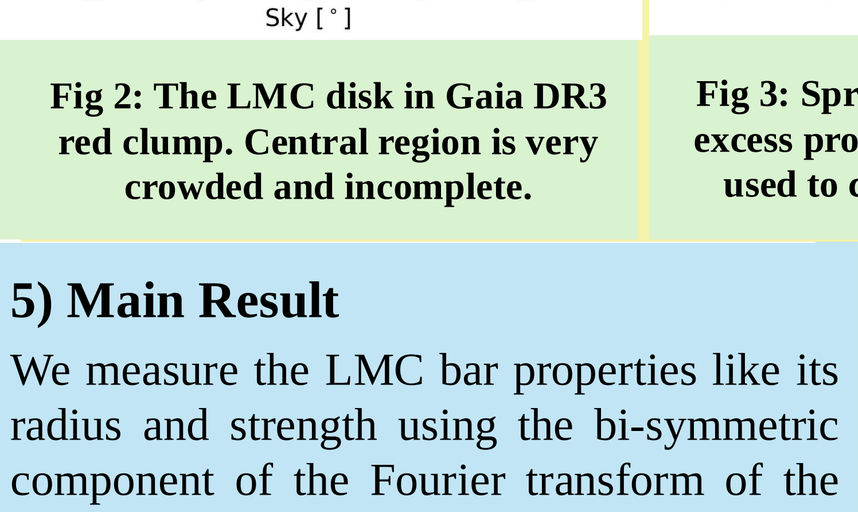


Fig 6. The Bar Radius - Bar Strength scaling relation.

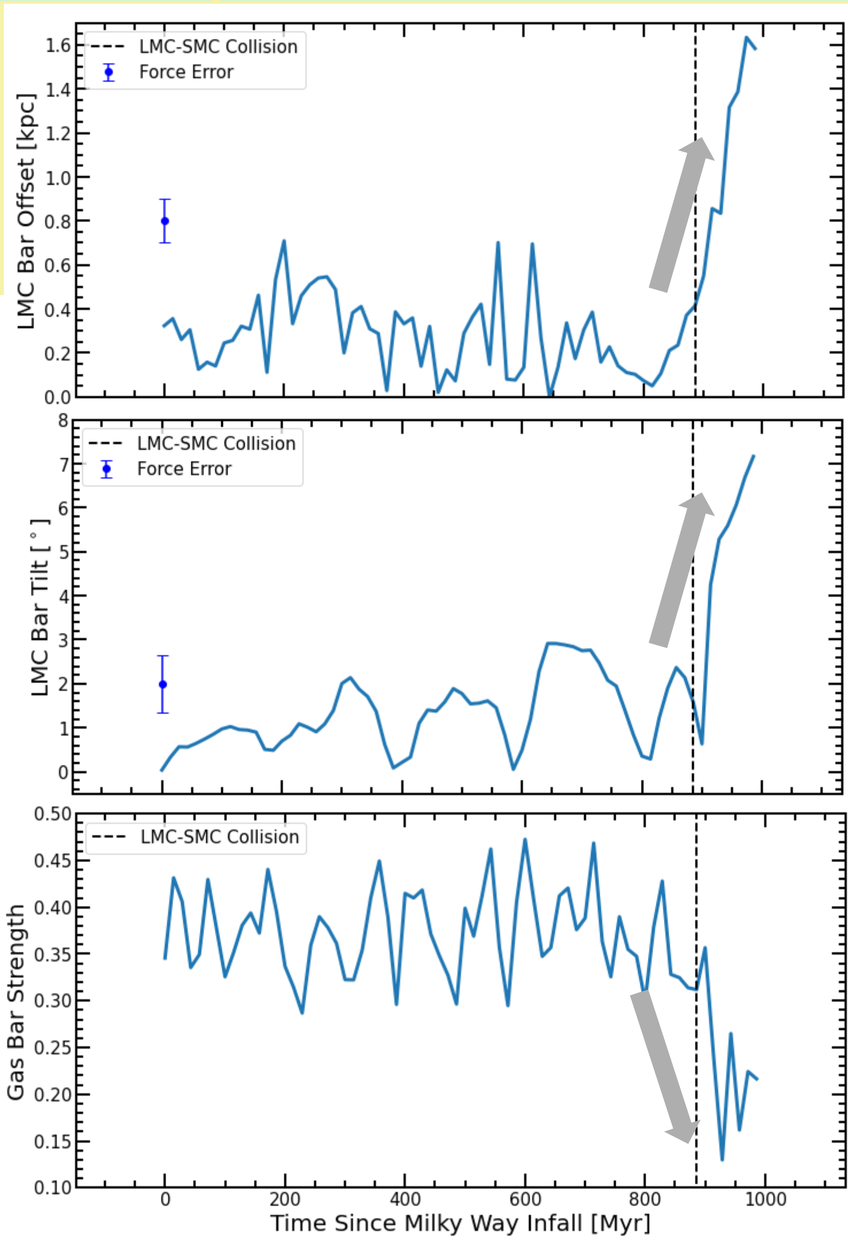
LMC Bar Radius = 2.13 (0.07) kpc
LMC Bar Strength = 0.27 (0.01)
LMC Bar Offset = 0.76 (0.01) kpc
LMC Bar Position Angle = 121.26 (0.21) deg
LMC Bar Axis Ratio = 0.54 (0.03)

6) The Origin of the LMC Bar's Strange Properties

We investigate a hydrodynamic model of the LMC - SMC - MW interaction history by Besla+2012 [2]. The LMC & SMC are modelled with live halos, exponential disks and SPH gas disks. The MW is treated as a static potential. The SMC undergoes a recent (~ 100 Myr ago) collision (impact parameter ~ 2 kpc) with the LMC. We find that in response to the SMC's collision, the LMC's bar:

- Gets offset from the disk center
- Gets tilted with respect to the disk plane
- Becomes significantly weaker in gas

Thus, a recent collision with the SMC explains the LMC bar's peculiar nature.



Based on Rathore+2024a (submitted, scan QR for draft) and Rathore+2024b (in prep)

Questions ?
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Major References:
[1] Besla et al. 2016; ApJ 825:20 (10pp), 2016 July 1
[2] Besla et al. 2012; MNRAS 421, 2109-2138 (2012)
[3] Athanassoula and Misiriotis 2002; MNRAS 330, 35-52 (2002)
[4] Olsen and Blum 2003; AJ 126:452-471, 2003 July
[5] Choi et al. 2022; ApJ 927:153 (13pp), 2022 March 10