Wide-field Infrared Survey Explorer

A WISE View of Nearby Spiral Galaxies: mapping the spatial distribution of star formation and stellar mass along the Hubble sequence

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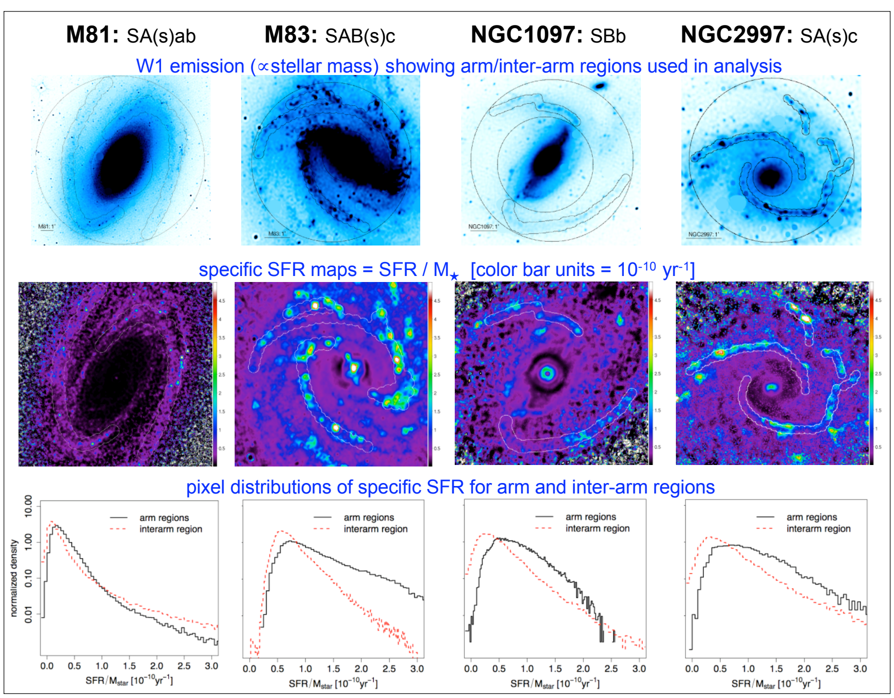
Goals

- We present results of a pilot study that uses WISE, archival UV data, and a new resolution enhancement technique to explore two long-standing hypotheses of the global star formation (SF) in spiral galaxies: **(i)** spiral density waves directly trigger SF through large-scale shocks along arms, or **(ii)** density waves simply reorganize and concentrate the ISM, stars and HII regions, and SF is induced by local (possibly self-propagating) stochastic processes, e.g., supernova shocks.
- Scenario **(i)** predicts an enhancement in the specific star formation rate (SSFR = SFR normalized to unit mass of disk material) along arms, mostly at their leading edge. **(ii)** predicts a spatially uniform SSFR across the disk. **(i)** was supported by Seigar & James (2002) using Hα and K-band data, while **(ii)** was recently supported by Foyle et al. (2010) using *Spitzer, GALEX* and CO data.
- In general, does the global SF mechanism vary with Hubble type, early vs late type, barred/non-barred morphology, spiral-arm pitch-angle, arm strength, total galaxy mass, and environment?
- Exploit and validate the use of WISE for nearby galaxy research, in particular the 12μm band.
- Advertise the benefits of resolution enhancement (HiRes) for WISE using a custom-built tool. This allows matching of spatial resolutions across wavelengths, in particular with archival data.

Procedure/Analysis

- Selected 12 relatively face-on spirals of different types from the 2MASS LGA (whose bands mostly trace the underlying stellar mass, not SF), and HiRes'd (with co-addition) the WISE frames for all bands using the algorithm of Masci & Fowler (2009). This included background matching, outlier and bad-pixel rejection, and masking/replacement of bright foreground stars. We then corrected for PAH emission and converted image pixels to absolute surface brightness units.
- Retrieved *GALEX* (FUV-band) images, corrected for MW extinction, and reinterpolated onto the WISE HiRes grid. The UV emission represents the "unobscured" SF component, while W3 (12μm) and W4 (22μm) were used to trace the "obscured" SF (ignoring cold-dust emission for now).
- Created spiral arm masks from the W1 images to delineate from interarm regions for analysis.
- Then constructed specific SFR maps using the stellar mass ($M_\star$) and SFR estimators derived by Leroy et al. (2008) from *Spitzer* data with parameters adjusted for WISE:

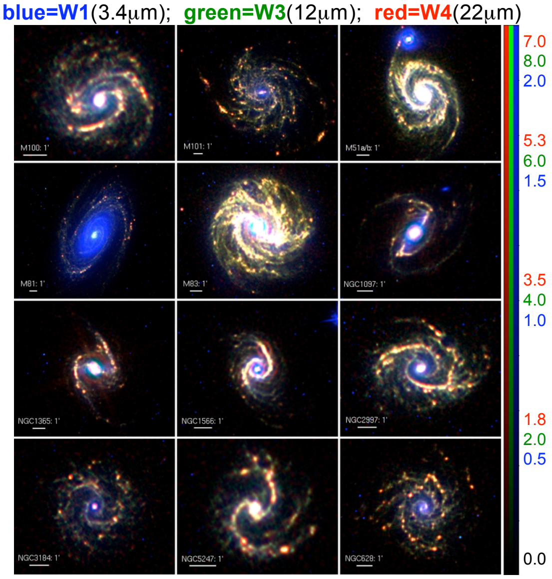
$$\frac{SFR}{M_*} = \frac{aI_{FUV} + bI_{W4}}{(M_*/L)_K \langle I_K / I_{W1} \rangle I_{W1}}, \quad \text{with } I_{W4} \approx I_{W3} \left\langle \frac{I_{W4}}{I_{W3}} \right\rangle_{W3beam}$$



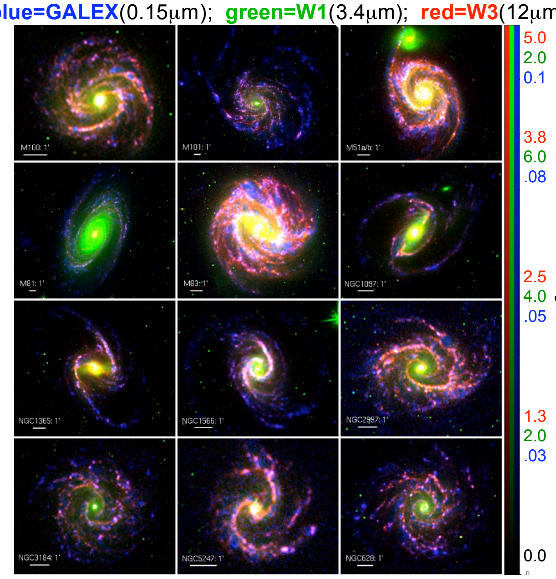
Summary of preliminary results

- Our HiRes processing allows us to resolve structure on scales of ~350 pc at a distance of ~25Mpc in W1,2,3 and twice this in W4. For comparison, the native WISE resolution probes scales ~2x larger than these.
- The specific SFR appears significantly enhanced in the arms of a majority of late-type grand-design spirals, supporting the large-scale density-wave shock scenario for SF. This enhancement is lowest in the arms of strongly barred spirals. Mid-IR-flocculent spirals include other local SF processes.
- Some arms show enhancements in specific SFR at their leading edge, but some also show this at their trailing edge. This needs more analysis.
- Future work will explore the distribution of molecular gas, SF efficiency, and extend the analysis to several hundred spirals in the local volume.

blue=W1(3.4μm); **green=W3**(12μm); **red=W4**(22μm)



blue=GALEX(0.15μm); **green=W1**(3.4μm); **red=W3**(12μm)



http://wise.astro.ucla.edu

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