Lessons from Comparisons between the Nuclear Region of the Milky Way and Those in Nearby Spirals.

Jay Gallagher, Tova Yoast-Hull, Ellen Zweibel (U. Wisconsin)

Thanks to NSF for support through IceCube & Center for Magentic Self Organization NASA via Hubble Space Telescope, & Donors to the University of Wisconsin College of Letters & Science
Objective: place Milky Way nucleus in context

- Milky Way CMZ nearby → best details (e.g., Sakamoto talk)

- Single example—unique vs. general characteristics
  - Supernova model cosmic ray interaction model fails in MW nucleus, works in NGC 253 (Tova Yoast-Hull poster): starburst ← normal
  - Low star formation rate (SFR)
  - Quiet SMBH
  - Fermi bubble
  - ....
Milky Way Nucleus in Context: Struturally Similar Nearby Mildly Barred Spirals

- IC 342 SAB(rs)cd D=3.5 Mpc $M_B = -21.9$
- Maffei 2 SAB(rs)bc: D=3.9 Mpc
- M83 SAB(s)c D=4.5 Mpc $M_B = -20.4$
- NGC 253 SAB(s)c D=3.9 Mpc $M_B = -21.2$
- Milky Way SABbc: $M_B \sim -20.5$
Similarities
Nuclear NIR Luminosities

IC 342

\[ \log(L_H) = 8.9 \]

Maffei 2

\[ \log(L_H) = 9.3 \]

See Poster 5: D Meier!
Nuclear NIR Luminosities

M83

Log($L_H$) = 9.3

NGC 253

Log($L_H$) = 9.2

2MASS JHK
Maffei 2 CO – Bar + CMZ Disk

$M_{\text{mol}}^{\text{CO}} \approx 5 \times 10^7 \text{M}_{\odot}$

Meier + 2008,
ApJ 675
NGC 253—Edge on CMZ


$M_{\text{mol}}(\text{CO}) \approx 1 \times 10^8 \text{ Msun}$

Sakamoto-NGC 253 Nucleus vs. MW CMZ

$M(\text{mol})_{\text{CO}} \approx 3-4 \times 10^7 \, M\text{sun}$

Sakamoto+ 2011
M83 NMA CMZ

\[ M(\text{mol})_{\text{CO}} \approx 5 \times 10^7 \, \text{Msun} \]

Muraoka + 2009, PASJ, 61

\[ M(\text{mol}\text{CO}) \approx 2 \times 10^7 \text{ Msun} \]
**Fundamental Similarities**

NIR luminosities of nuclear complexes in MW & neighbors are similar → stellar masses $M_\star \approx \text{fewE8 Msun}$

Molecular masses deduced from CO measurements yield similar masses in range $\approx 1-10\text{E7 Msun}$
And Major Differences
Approximate Nuclear SFRs

- **Milky Way**
- **IC 342**
- **Maffei 2**
- **M83**
- **NGC 253**

Log (SFR) $\text{Msun/yr}$
SFR – Pressure-Wind Connection

Starburst — “heat is on”; $P/k \approx 10^6$-7; 10-100 x MW CMZ thermal pressure
Milky Way – NGC 253 Nuclei γ-Rays
SFR? Molecular Mass? B-Fields? U(rad)? Winds?
de Naurois Talk, Yoast-Hull+ Poster 37
Milky Way – NGC 253 CMZ Radio
SFR? CR proton/electron, B-Fields? U(rad)? Winds? Yoast-Hull+ Poster 37
SFR - M(mol) Relationship
Bimodal Behavior?

Log [SFR] Msun/yr

Log [M(mol)_{CO}] Msun
Star Formation Intensity: Key Factor in Milky Way-Like Nuclei

✧ Range in SFR intensity ~100

✧ Not tied to CO-based molecularISM mass; doesn’t follow mean trends in galaxy disks

✧ Large range in efficiency of star formation?

✧ SFR does not appear to correlate with nuclear zone stellar mass

✧ Milky Way center now in SFR down phase
Episodic Star Formation

Long expected given fueling inflow & short dynamical times. E.g, Bally Talk, Su P77,


MOLECULAR GAS AND THE NUCLEAR STAR CLUSTER IN IC 342: SUFFICIENT INFLOW FOR RECURRING STAR FORMATION EVENTS?

GIANT GAMMA-RAY BUBBLES FROM FERMI-LAT: ACTIVE GALACTIC NUCLEUS ACTIVITY OR BIPOLAR GALACTIC WIND?
Su, Slatyer, Finkbeiner 2010, 724
But Beware of Possible Details

- Physical state of molecular gas varies due to extreme environment: temperature, chemistry (Aalto talk), turbulence, …

- If star formation levels bimodal, then need a transition from inactive to active states. Not simply mean molecular mass—but maybe molecular medium structure (dense cores)

- Watch out for unexpected impacts from the SMBH!
The Astronomical Journal: Innovating to Improve Scientific Communication

- Instrumentation/software articles
- Electronic presentation of data; data behind figures, FITs data sets
- Video content
- (Public abstracts – in the works)
- Other ideas? Email: aj@astro.wisc.edu