OBSERVATIONAL COSMOLOGY:

GALAXY EVOLUTION WITH RADIO

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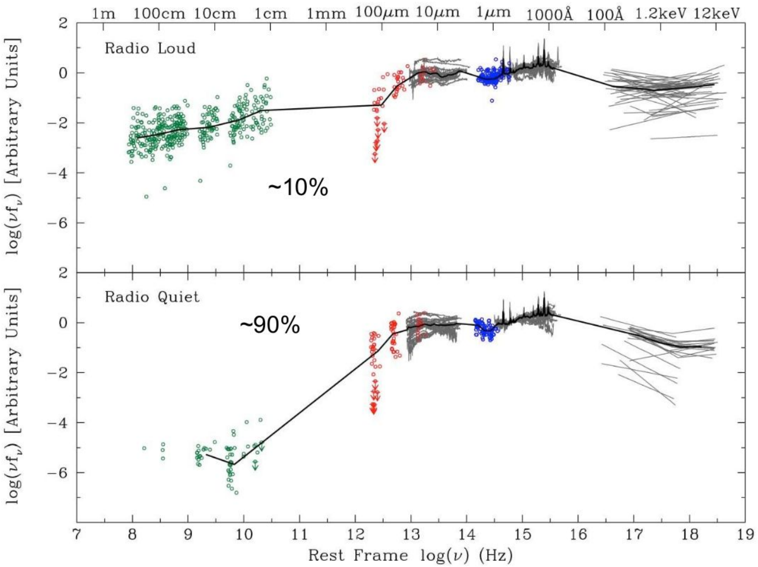
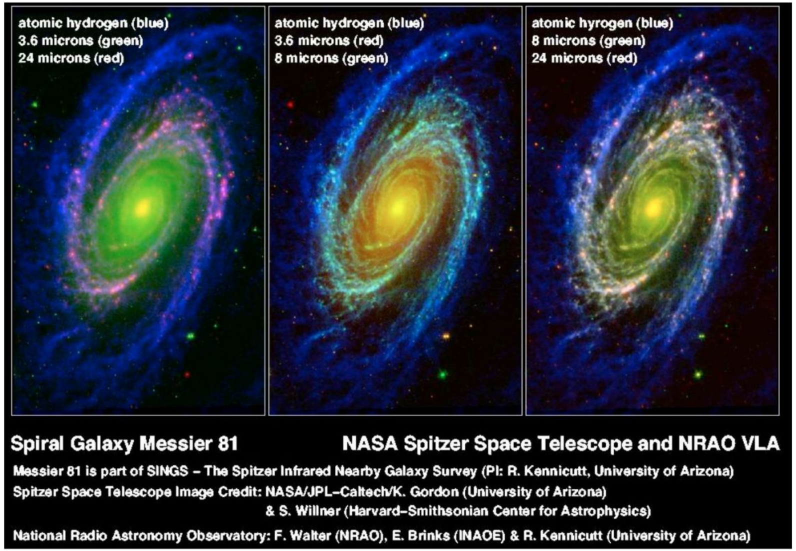
GALAXY EVOLUTION FROM RADIO OBSERVATION

From radio observations we can get information on:

- **Gas content (molecular and atomic)**
- **Nuclear activity and its impact on galaxies**
- **Star formation rates**





STAR FORMATION TRACER

A star formation tracer ideally should be:

- **Unobscured**
- **Independent of viewing angle**
- **Not a function of environment**
- **Redshift invariant**

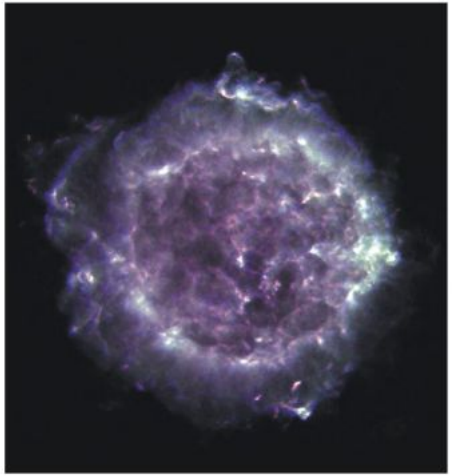
NGC 4038/4039

IC10

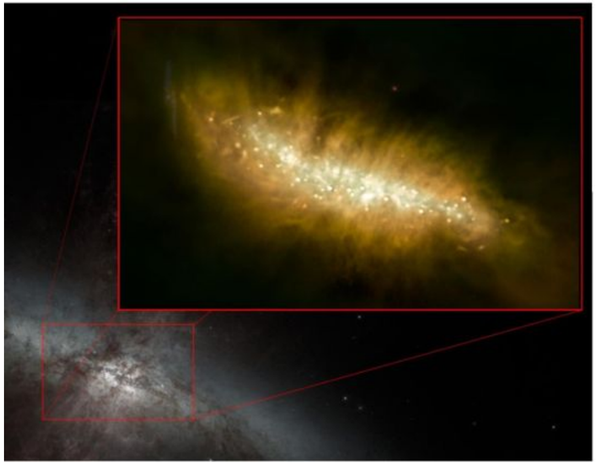
M82

RADIO CONTINUUM AS SF TRACER

- **Massive stars exploding in SN produce remnants (relativistic e^- + strong magnetic fields) that produce synchrotron radiation**
- **Galaxies with high SFR will have also high SN rate, and thus associated synchrotron emission**
- **Integrated radio flux serves as a transparent proxy for the total population of young, massive stars.**



Cas A supernova remnant
VLA 1.4/5/8.4 GHz

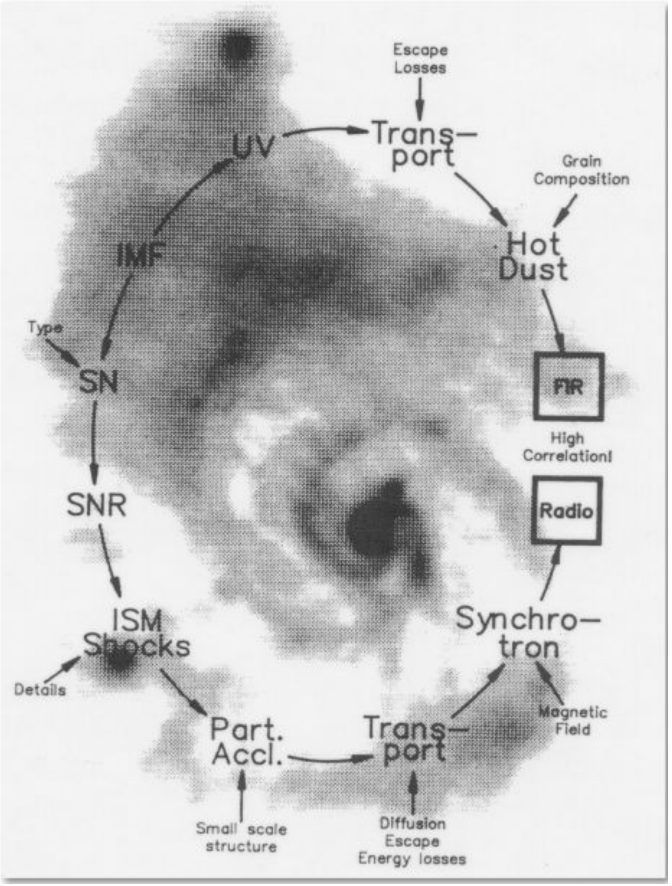


M82 - a nearby typical star-forming galaxy
radio continuum

GALAXY IR AND RADIO CONTINUUM

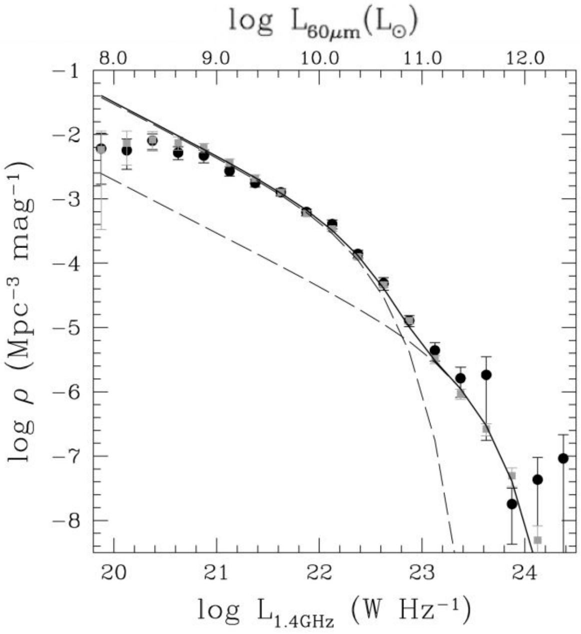
IR and (synchrotron) radio emissions trace the same star formation processes, but are affected by different systematics:

- **IR emission is affected by:**
  - **IMF modeling**
  - **UV photon transport**
  - **optical depth**
  - **dust grain distribution/composition**
- **Radio emission is affected by:**
  - **IMF modeling**
  - **acceleration mechanisms**
  - **primary/secondary e^-**
  - **magnetic fields**
  - **transport (diffusion & confinement)**

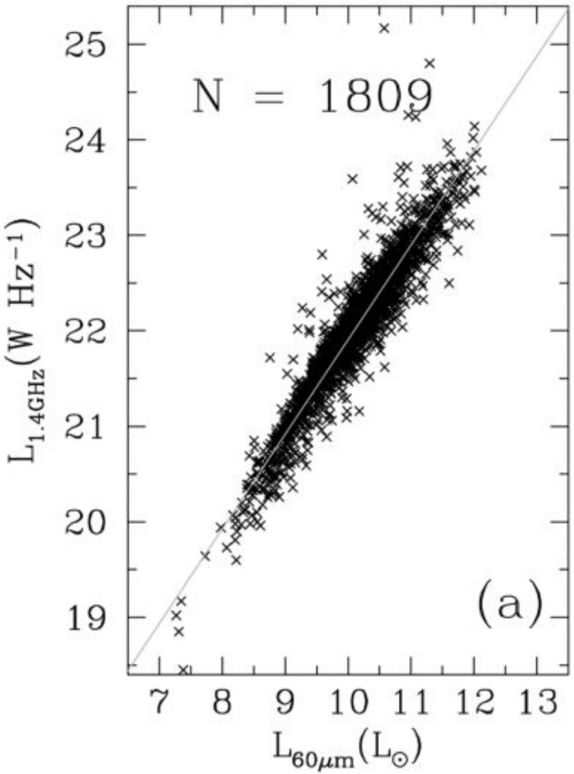


GALAXY IR AND RADIO CONTINUUM

Since the life cycle of massive stars regulate both the non-thermal radio (synchrotron) emission and the IR emission (re-radiated UV light), we expect strong correlation between them:



Radio & 60 mm luminosity functions of galaxies in the local IRAS 2 Jy-sample (Yun+ ‘01)

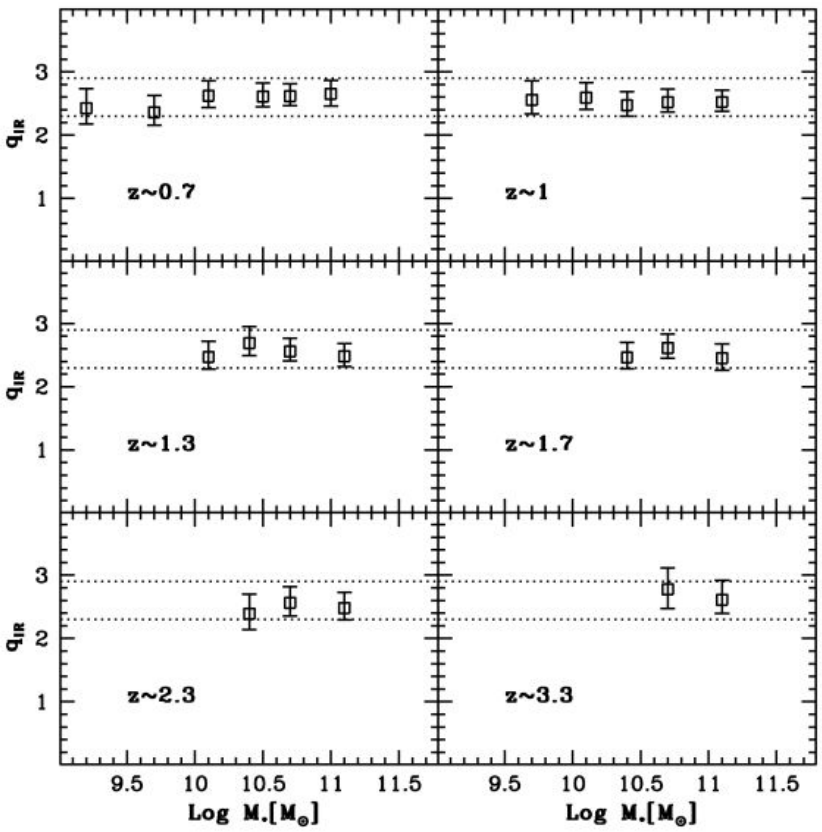


GALAXY IR AND RADIO CONTINUUM

The correlation between radio and IR luminosity can be expressed in terms of the coefficient:

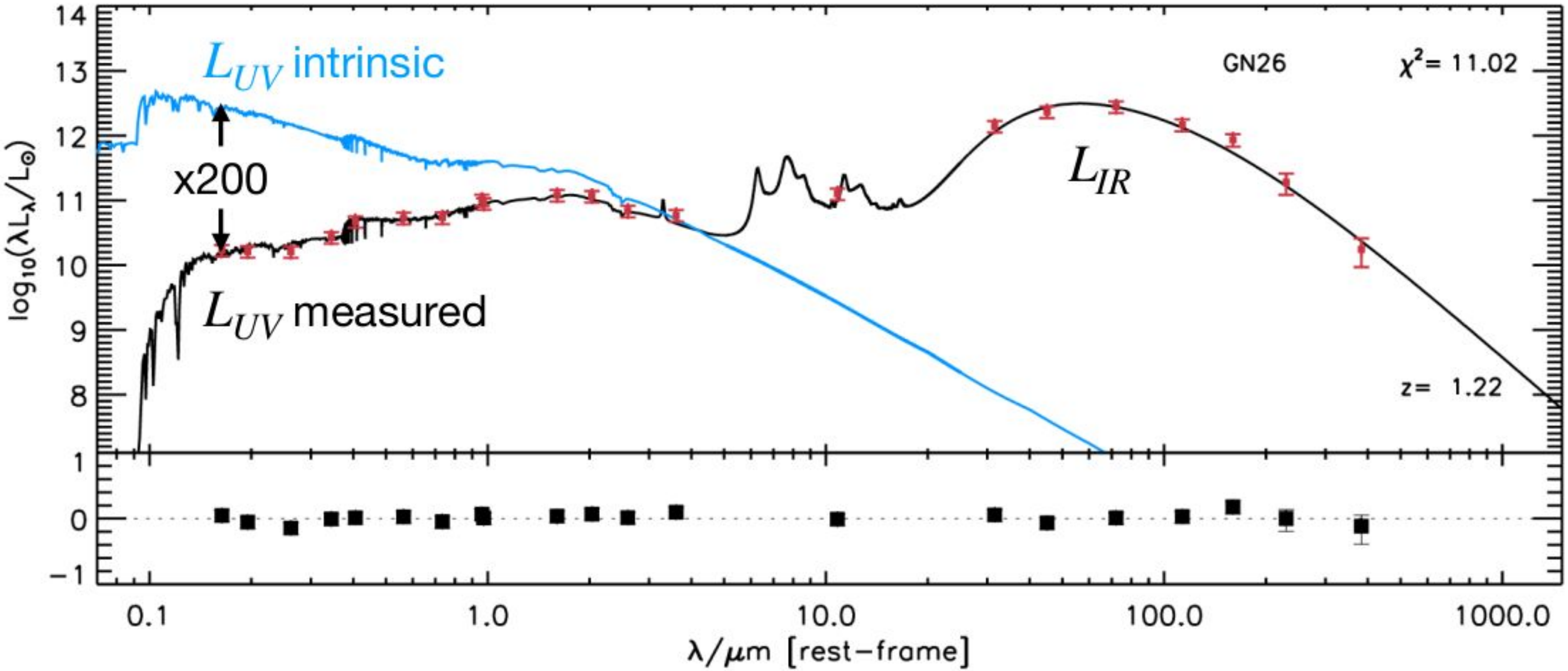
$$q_{\rm IR} = \log \frac{L_{\rm IR}/(3.75 \times 10^{12}{\rm W})}{L_{1.4}/{\rm WHz^{-1}}}$$

- **The correlation holds up to high redshift**
- **Correlation ~constant with respect to redshift and stellar mass of the galaxy (q_{IR} ≃ 2.3)**



RADIO CONTINUUM AS SF TRACER

The IR-radio correlation is extremely valuable to determine the SFR:



RADIO CONTINUUM AS SF TRACER

The IR-radio correlation is extremely valuable to determine the SFR :

- **We want to measure:**

$$SFR = \kappa_{UV} \cdot L_{UV}[intrinsic]$$

- **Just looking at the UV luminosity we can estimate from SED fitting:**

$$SFR = \kappa_{UV} \cdot L_{UV}[measured] \cdot 10^{A_{UV}/2.5}$$

- **Assuming that the energy is conserved we can estimate SFR from IR or radio luminosity:**

$$SFR = \kappa_{UV} \cdot L_{UV}[measured] + \kappa_{IR} \cdot L_{IR}$$

$$SFR = \kappa_{UV} \cdot L_{UV}[measured] + \kappa_{radio} \cdot L_{radio}$$

STAR FORMATION TRACERS

	UV	IR	Radio
PROS	- Easy to collect / high sensitivity - High resolution	- Robust estimator (20% accuracy)	- ×2 accuracy (better than UV, but more “indirect” than IR) - Easy K-correction - Ground based observation - Wide FoV
CONS	- SFH dependent - Need UVJ Selection - Strongly affected by dust (up to ×5 accuracy)	- Poor resolution / Sensitivity - Space-based observation - Most high-sensitivity IR camera has small FoV - Dust/PAH composition dependent	- Poor sensitivity - Rely on Radio-IR correlation - Need UVJ selection