The ISM in Infrared Bright Galaxies - First Results from SHINING

E. Sturm

for the SHINING Team
1) SHINING Goals

The physical processes in the interstellar medium of local, infrared bright galaxies

PACS (+ SPIRE) Photometry and Spectroscopy

Starbursts, AGN, ULIRGs

Interacting Galaxies

Dwarf Galaxies

The objects cover a wide parameter range in
- luminosity,
- activity level, and
- metal enrichment,
complemented by objects at intermediate redshifts (1-3), i.e. at a more active epoch of star formation.
ISM in IR-bright Galaxies - SHINING

Herschel First Results Symposium, ESLAB 2010

E. Sturm

[C II] 158 \, \mu m

[M82]

[O I] 63 \, \mu m

[O I] 145 \, \mu m

[C II] 158 \, \mu m

[O III] 88 \, \mu m
ISM in IR-bright Galaxies - SHINING

Herschel First Results Symposium, ESLAB 2010

E. Sturm

$\text{[C II]}$ velocity

$\frac{\text{[O III]}}{\text{[C II]}}$

$\text{[O III]}$ velocity

$\text{[C II]}$ 158 $\mu$m

$\text{[O III]}$ $\sigma$

$\text{[O III]}/\text{[C II]}$
ISM in IR-bright Galaxies - SHINING

M82

[O III] / [C II]

[C II] 158 μm

[O III] σ

[Talk by A. Contursi]

Contursi+ in prep
Contursi+ in prep
Dwarfs / Low metallicity - NGC 4214

Talk by S. Madden
Poster P1.43 by N. Cormier
Cormier+ 2010


Low metallicity + intense star formation →
- high [O III] / [C I]
- \( \frac{L(\text{FIR lines})}{L_{\text{TIR}}} = 2\% \)
- extreme CII/CO, ISM strongly affected by photodissociation

Irregular Magellanic type galaxy
2.9 Mpc away
Metallicity: 1/3 solar
Interacting galaxies – resolving the star formation sites with PACS photometry

Hubble Space Telescope

Herschel First Results Symposium, ESLAB 2010

E. Sturm
Interacting galaxies – resolving the star formation sites with PACS photometry

Talk by U. Klaas

Klaas+ 2010
Interacting galaxies – resolving the star formation sites with PACS photometry.
ISO’s Heritage – The “CII deficit”

Luhman+ 2003
[O I] 63\,\mu m
[O I] 63μm
ISM in IR-bright Galaxies - SHINING

[O I] 145μm
[C II] 157µm
ISM in IR-bright Galaxies - SHINING

- HII galaxies
- LINERs
- AGN
- z > 1

Large symbols = SHINING
ISM in IR-bright Galaxies - SHINING

Hailey-Dunsheath+ 2010 and in prep.

MIPS J1428

NGC4418
The roles of Major Mergers vs. Steady Accretion, and the SFE

Genzel et al. 2010, Tacconi et al. 2010
ISM in IR-bright Galaxies - SHINING

[C II] - deficiency

Line - deficiency

\[
\begin{align*}
\text{[C II]} & \quad 158\mu m \\ 
\text{[O I]} & \quad 145\mu m \\ 
\text{[N II]} & \quad 122\mu m \\ 
\text{[O III]} & \quad 88\mu m \\ 
\text{[O I]} & \quad 63\mu m \\ 
\text{[N III]} & \quad 57\mu m \\ 
\text{[O III]} & \quad 52\mu m \\ 
\text{[S III]} & \quad 18\mu m \\ 
\text{[Ne III]} & \quad 15\mu m \\ 
\text{PAH} & \quad 6.2\mu m
\end{align*}
\]

\[
L_{\text{FIR}} / M_{\text{H}_2} \left[ \frac{L_{\odot}}{M_{\odot}} \right]
\]
CLOUDY modelling

High SFE $\rightarrow$ compact star formation $\rightarrow$ High U $\rightarrow$ low line/FIR ratio

Abel + 2005, 2009
Garcia-Carpio+ in prep
Spectroscopy of luminous galaxies at z>1

MIPSJ142824.0+352619
z = 1.32
**ISM in IR-bright Galaxies - SHINING**

**MIPSJ142824.0+352619**

$z = 1.32$

The Luminosity of a ULIRG

but

The SFE of a normal starburst

**Talk by A. Verma**

Sturm et al. 2010

---

Herschel First Results Symposium, ESLAB 2010

E. Sturm
Spectroscopy of luminous galaxies at z > 1

IRAS F10214+4724
z = 2.2855
Spectroscopy of luminous galaxies at z>1

(ISM in IR-bright Galaxies - SHINING)

Herschel First Results Symposium, ESLAB 2010

E. Sturm
Molecules

**NGC4418**

![Graph showing molecular emissions in NGC4418](image)
NGC 4418 – a unique extragalactic astro-chemical laboratory

- $N(H_2O) = 10^{19} \text{ cm}^{-2}$
- covering factor 50%
- High critical density lines – radiatively pumped

Poster P1.48 by S. Hailey-Dunsheath

Hailey-Dunsheath+ in prep.
Catalogue of (tentatively) identified molecules in PACS spectra of IR-bright galaxies – so far.

Poster P1.57 by E. González-Alfonso
[O I] in the Milky Way, seen in absorption in the line of sight to the Circinus Galaxy (close to the galactic plane)
OH – Massive molecular outflow in Mrk 231
AGN feedback at work?

Outflow mass of $7 \times 10^7$ M$\odot$
Outflow velocities of $-1400$ km/s
Mechanical energy $\geq 10^{56}$ ergs

Talk by
J. Fischer
OH – Massive molecular outflow in Mrk 231
AGN feedback at work?

Outflow mass
Outflow velocity
Mechanical energy
Compare: OH in Seyfert Galaxies:
High J CO - the new toy

Schleicher+ 2010

rotational CO transition
ISMS in IR-bright Galaxies - SHINING
CO (18-17) vs. CO (1-0)

HST + Chandra

IRAM PdBI (Schinnerer et al. 2003)
Circinus Galaxy

\[ \lambda \ [\mu m] \]
1) Rich harvest of FIR diagnostic lines and images in starbursts, AGN, ULIRGs, at different redshifts, metallicities, and interaction stage, with spatial and kinematic information

2) Global Line/FIR deficiency at high $L_{\text{FIR}}/M_{\text{mol}}$ – high ionization parameter?

3) Molecules galore – complex astro-chemistry and ISM processing

4) Massive molecular outflows – AGN feedback?

5) High J CO Lines in AGN – cooling the torus?
### Talks by
- A. Contursi
- S. Madden
- U. Klaas
- A. Verma
- J. Fischer

### Posters by
- S. Hailey-Dunsheath (P1.48)
- J. Graciá-Carpio (P1.60)
- D. Cormier (P1.43)
- E. González-Alfonso (P1.57)

### A&A papers by
- Fischer+ (Mrk231)
- Cormier+ (NGC4214)
- Klaas+ (Antennae photom.)
- Sturm (high-z ULIRGs)