Definitive characterization of the ISM in the Local Universe: SKA and other facilities

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The II National Workshop of SKA science and technology, Bologna, 3 – 5 December 2018
DustPedia - A Definitive Study of Cosmic Dust in the Local Universe (FP7-SPACE proj. 606847)
PI: Jon Davies (Cardiff University). 6 European nodes.

A legacy database of 875 galaxies observed by Herschel (HRS, KINGFISH, HeViCS...). D_{25} > 1', v < 3000 km/s, multiwavelength coverage from UV to submm (up to 42 bands/ galaxy)

DustPedia Database:
http://dustpedia.astro.noa.gr/
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ESKAPE-HI
Empowering SKA as a Probe of galaxy Evolution with HI
PI: L. Hunt (INAF-Arcetri)
Interstellar medium (ISM) & ISM scaling relations

ISM: primary importance for the formation and evolution of galaxies since it is in the environment from which stars are formed

- Mass of ISM: gas for ~99% (~74% of H, ~25% of He, ~1% of heavier elements, i.e. ‘metals’), dust for ~1%
- Nearby galaxies: Intricate system of correlations between their global properties, called scaling relations
- Scaling relations: correlations between physical properties, internal physics, formation and evolutionary histories, different galaxy populations
- In the last years, the number of works on the ISM scaling relations has grown
- Dust often neglected, sometimes the molecular gas/ metallicity are neglected, …
ISM scaling relations in the Local Universe (DustPedia)

Sample and data:

- 436 late-type (T = 1 – 10, Sa – Irregular) DustPedia galaxies (Davies+17)
- Dust mass (THEMIS dust mass model, Jones+17) [IR data from Herschel]
- CO and HI (gas mass) data (Casasola+, in prep.) [mm and cm data from radio telescopes (single-dish/interferometer)]
- Metallicity data (De Vis+18, submitted) through multiple strong-line calibrations

DustPedia sample + DustPedia data + DustPedia ancillary data: “ideal” project to characterize the ISM scaling relations in the Local Universe
ISM scaling relations in the Local Universe
(DustPedia)

Dust and gas components (HI, CO → H₂, HI+H₂)
ISM scaling relations in the Local Universe (DustPedia)

Dust and gas components (HI, CO→H₂, HI+H₂)

Both dust and gas masses are referred to the optical disk ($r_{25}$)

Casasola et al. in prep.
ISM scaling relations in the Local Universe
(DustPedia)

Dust and gas components (HI, CO→H₂, HI+H₂)

Both dust and gas masses are referred to the optical disk ($r_{25}$)

Dust and molecular gas are well correlated

Consistent with star formation process

The correlation does not improve assuming a CO → H₂ conversion factor ($X_{CO}$) depending on the metallicity (e.g., Sandstrom+13; Hunt +15; Amorin+16)

Casasola et al. in prep.
ISM scaling relations in the Local Universe (DustPedia)

Dust and gas components (HI, CO→$\text{H}_2$, HI+H$_2$)

Both dust and gas referred to the optical disk ($r_{25}$)

Dust and atomic gas (21cm-HI) are better correlated than dust and molecular gas

Opposite to what happens at small scale physics

Casasola et al. in prep.
ISM scaling relations in the Local Universe (DustPedia)

Dust and Gas components (HI, CO→$H_2$, HI+$H_2$)

Both dust and gas referred to the optical disk ($r_{25}$)

Dust and total gas are well correlated and the correlation is driven by HI in the galaxy disk

Scaling relations tested with a large and homogenous sample and under several assumptions: constant $X_{CO}$ (Bolatto+13), $X_{CO}$ depending on O/H (Amorin+16)

Casasola et al. in prep.
Dust-to-gas mass ratio (DGR), metallicity, morphology

$X_{\text{co}}$ depending on $Z$ reproduces the expected decreasing of DGR with $T$ (see, e.g., Draine+07, Rémy-Ruyer+14, Hunt+15, Relano+18)

We characterize DGR at a given $T$ for all gas phases

Casasola et al. in prep.
**Evolution:**

HI is dominant when dust is yet in small quantities wrt total gas.

H$_2$ is dominant when dust is already destroyed.
Dust/Tot gas vs. $H_2/\text{HI}$

The peak of DGR at intermediate ages.

The DGR is reduced for more evolved galaxies, possibly as an effect of differential consumption of dust and gas during astration.

**GALAXY EVOLUTION**: Science driver of SKA
ALMA, *(Herschel $\rightarrow$ SPICA)*, DustPedia Project, PRIN SKA ESKAPE-HI
ISM scaling relations in the Local Universe

Conclusions
in SKA perspective
in perspective of synergies between SKA and other facilities

✓ HI @ 21cm (1.4 GHz): fundamental role to characterize the ISM in the disks of the Local Universe

✓ ALMA is revealing the molecular gas through several tracers (e.g., CO) at mm $\lambda$, telescopes as JVLA and, in future, SKA detect the HI gas component

✓ Our approach is an example of synergy between SKA pathfinder/precursors, ALMA (IRAM, Nobeyama), and Herschel, ...

✓ Once characterized the ISM at $z = 0$: What happens at $z > 0$? What happens at the small-scale physics?

SKA + other facilities will surely help us!
Thanks!
436 late-type DustPedia galaxies

- 50%: interacting galaxies, including pair and group members
- 12%: low-luminosity AGN ($L_X < 10^{42}$ erg s$^{-1}$) including Seyferts and LINERs
- 2%: starbursts