Views of Interstellar medium in galaxies in the ALMA era

By Nofoz Suleiman (n.suleiman@astro.elte.hu)
Doctoral School of Physics - ELTE
ELTE Talent Support, Spring 2019
Dec. 10, 2019

Views of Interstellar medium in galaxies in the ALMA era held on September 2nd - 06th 2019 at the heart of the Monumental Complex of San Giovanni in Monte (Bologna, Italy). It is intended for students, post-docs, professors and scientists who want to present their latest researches related to ISM in galaxies in the ALMA era, the contributions were talks, posters or even by attendance. My contribution was a poster talking about the dust and star-formation in dust-obscured galaxies and SED modeling using CIGALE.

Galaxies accrete gas from the intergalactic medium, thus building their gaseous reservoirs, which fuel the formation of stars and the growth of super-massive black holes. Feedback mechanisms then return part of this material into the circum-galactic environment, thus completing the so-called `baryon cycle'. Understanding this process and its dependence on different galaxy properties and cosmic times is one of the key-question of modern astrophysics and is very challenging, given the complexity and interplay of the physical mechanisms involved and the difficulty to be observed the interstellar gas in distant galaxies.

The advent of the power of the Atacama Large Millimeter Array (ALMA) and the upgraded capabilities of other sub-mm/mm facilities are now opening a complete new window of the baryon cycle. On one hand, local galaxies are exploited as 'laboratories' where the interstellar medium is studied down to molecular cloud scales and the physical processes can be investigated in detail. On the other hand, thanks to the unprecedented sensitivities of the new facilities, systematic surveys of the gaseous content in high redshift galaxies are starting to characterize the gas cycle throughout cosmic time. Dedicated observations have revealed gas in the most distant galaxies, all the way to the reionization epoch, and have started to dissect the interplay between luminous active galactic nuclei and their host galaxy. These new observational constraints are guiding the next generation of galaxy evolution models.

The aim of the conference was to review the latest results on extragalactic studies of the baryon cycle, obtained thanks to IR/(sub-)mm facilities, and in particular with ALMA, and to discuss their impact and consequences on our understanding of galaxy evolution from nearby galaxies up to the early Universe.

During the conference's days, there were many of effective reviews, talks and researches given by profs and experts from over the world. The first day was talking about the Local Universe; ALMA Brings Molecular Gas in Galaxies Into Focus, Demographics and Environment-dependence of Molecular Cloud Properties, The Cloud-scale Baryon Cycle of Nearby Galaxies, A systematic characterization of the evolutionary cycling between molecular clouds, star formation, and feedback in nearby galaxies, …, and other topics.

In the second day, the active gala nuclei was the head topic, where (Sub) millimetre observations of z>6 quasar hosts: massive galaxy formation in the epoch of re-ionization, ALMA Reveals the Interstellar Medium Dynamics of Hyper-luminous Obscured Quasars, The molecular gas content of obscured Quasars at high-z, AGN in dusty Starbursts at z=2: feedback still to kick in, Feeding and feedback in dusty galaxy nuclei and AGNs, Gas dynamics at z=4.8 with high-resolution ALMA observations and other interested topics were discussed.

In the latest days, the topics were talking about high redshift galaxies, several surveys, and some of theories. For instance; The new era of galaxy evolution studies from sensitive molecular and dust deep field surveys, Dust Emission from z>=2 Lyman-Break Galaxies in the HUDF ASPECS Program, High resolution ALMA imaging of SMGs, A theoretical view of dust in galaxies near and far, Kinematics and dynamics of molecular gas in high redshift quasars, An ALMA view of galaxies in the Epoch of Reionisation, Extremely cold dusty galaxies at z=4-6: first direct evidence of CMB impact on high-z galaxy observables, and Properties of galaxies at z ~ 6 - 9 revealed by ALMA.

The conference's web-page: https://eventi.unibo.it/ism-difa-bologna-2019/important-dates

Group Picture:

My poster:

Dust and star formation in dust obscured galaxies
and SED modeling using CIGALE

Nofoz Suleiman[1 *], Yoshiki Toba [2], Akatoki Noborighuchi [3], Gabor Marton [1], Sandor Frey [4], L. V. Toth [1]

[1] Astronomy department, Eötvös Loránd University, Hungary. [2] Kyoto University, Japan. [3] Ehim University, Japan.

[4] Konkoly observatory, MTA CSFK, Hungary

Introduction

Dust-obscured galaxies (DOGs; Dey et al. 2008) are originally defined as galaxies that are bright in mid-infrared (MIR) while faint in optical. The interstellar medium and star formation of distant galaxies may be revealed using advanced spectral energy distribution (SED) modelling. Such models, however, require a knowledge of the mid and far-infrared luminosities (Hopkins et al. 2006).

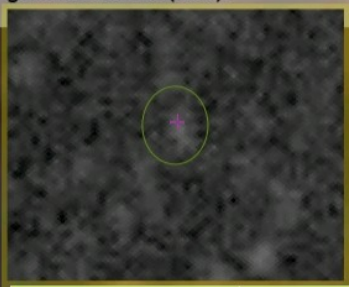
Recently, DOGs shed light on the co-evolution issue, because supermassive black holes (SMBHs) in DOGs are expected to be rapidly growing during the co-evolution. One scenario of the mass accretion onto SMBHs is a major merger of two gas-rich galaxies, which first causes active star formation (SF), and then the gas accretion to the nuclear region triggers the activity of SMBHs as active galactic nucleus (AGN).

Methodology

We used the the Code Investigating GALaxy Emission (CIGALE) software package (Noll+2009, Roehlly +2014) for SED fitting. The program fits the SED from the far-ultraviolet to the radio, and different models can be chosen for the various media and physical processes in galaxies.

Several properties can be constrained by CIGALE: star formation rate (SFR), AGN luminosity, stellar mass and other parameters.

We used the Bruzual and Charlot Simple Stellar Population models, a delayed star formation history with an exponential burst, the Drain and Li model for the dust emission, and Calzetti model for the attenuation.

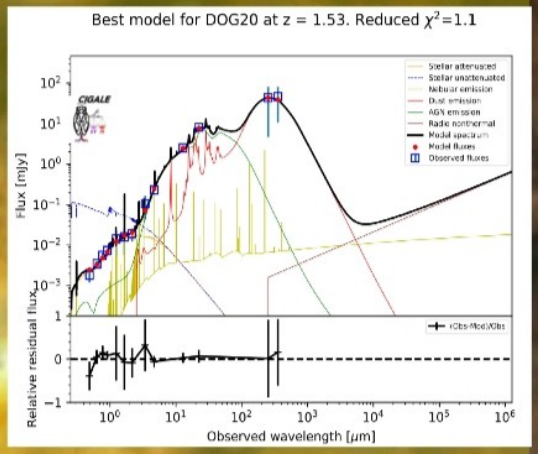


Results

As an illustration, we present the SED with the main properties of one of our sample of infrared-bright DOGs.

Herschel image from the 250 μm SPIRE observation is showed in the left-hand side.

	Best Fitting	Upper Limit	Lower Limit
SFR ($M_\odot$/yr)	507.5	701.4	313.3
AGN Luminosity ($\times 10^{39}$W)	1.9	2.18	1.21
Stellar mas ($\times 10^{10} M_\odot$)	9.0	9.5	7.9



Data usage

Our research is based on the latest "all sky" photometry of Herschel point sources systematically and homogeneously extracted from thousands of observations.

By Combining wide and deep optical images obtained with the Hyper Suprime-Cam on the Subaru Telescope, VISTA VIKING survey and WISE all-sky mid-infrared images taken with Wide Field Infrared Survey Explorer satellite, 427 IR-bright DOGs are discovered by (Noboriguchi et al. 2019). The photometric redshifts were determined between (0.9<z<2).

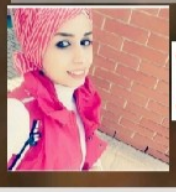
Discussion

Our results show reasonable SEDs and fitted values of the most important properties of such type of galaxies. In addition, these sources were determined the luminosity function $(9.5\pm1.1)\times10^{39}$ W, by creating a flux-limited subsample of DOGs by (Toba et al. 2015), this luminosity function matches our luminosities' values, that gives more reliability of CIGALE fitting and our results.

Such type of dusty galaxies with reliable parameter values enable us to study the transition phases of AGN evolution.

Acknowledgements

Best thanks to Tempus Public Foundation,
Doctorate school at ELTE University,
Data sources: Herschel catalog and Hyper Super-Cam Subaru Program,
The staff of Astronomy department at ELTE University.



• *Contact* n.suleiman@astro.elte.hu

• http://astro.elte.hu/~nsuleiman/

References

Bruzual, G., & Charlot, S. 2003, MNRAS, 344, 1000
Calzetti, D., Armus, L., Bohlin, R. C., et al. 2000, ApJ, 533, 682
Draine, B. T., & Li, A. 2007, ApJ, 657, 810
Dey, A., Soifer, B. T., Desai, V., et al. 2008, ApJ, 677, 943
Hopkins et al. 2008, ApJS, 175, 356
Noboriguchi, A., Nagao, T., Toba, Y., et al. 2019. ApJ, 876, 132
Noll, S. et al, 2009, A&A, 507, 1793
Toba, Y., Nagao, T., Strauss, M. A., et al. 2015, PASJ, 67, 86