Fourth Semester Report (2018/2019 Spring)

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Ph. D. Thesis Topic: Star formation and active galactic nuclei

Introduction

One of the key questions in extragalactic studies is to understand the evolution of galaxies, namely their star formation history, formation of active galactic nuclei (AGN), building-up of large disks and bulges and the formation and evolution of supermassive black holes over the redshift range from $z \approx 5$ to the present epoch. This is the range where the global star-formation rate has passed through a maximum between a redshift of 1 and 2 (Madau et al. 1996; Madau, Pozzetti & Dickinson 1998; see the recent compilation by Hopkins & Beacom 2006). It is conjectured that merging of galaxies has occurred significantly at these epochs, triggering collapse of molecular clouds and star formation, often in dusty environments. Many of these galaxies may also harbour an AGN and are copious emitters in the infrared region of the spectrum. It has become clear over the last decade that a population of galaxies which radiate most of their power in the infrared constitutes an important and significant component of the Universe (Lagache, Puget & Dole 2005 for a review).

Summary of research work in the previous semesters

In my first year of doctoral school, the physical properties of all possible AGN galaxies were studied with different redshift ($0.04<z<1.6$) in ELAIS N1 field. I have constructed a catalogue including 44 galaxies based on the new Herschel point source catalogue data combined with Sloan Digital Sky Survey (SDSS), 2MASS, Spitzer, WISE and other archival photometry data. Sources were taken from the HerMES CATALOG (R. S. Bussmann. et. al. 2015) and the WISE AGN CATALOG (R.J. Assef et. al. 2017). I have plotted spectral energy distributions (SEDs) that cover the rest-frame wavelength ranges from far-UV to far-IR (from 0.15 to 160 micrometre). The SEDs have been then modelled using the Code Investigating GALaxy Emission (CIGALE) software package (Noll+2009, Roehlly +2014), deriving galaxy properties with a high reliability by fitting the attenuated stellar emission and the related dust emission at the same time. The 44 galaxies were sorted into 4 different types of AGNs: 7 Sy1, 5 Sy2, 31AGN and 1 BSG. The CIGALE fitting resulted a large number of physical quantities for each galaxy. I have focused on certain quantities in my research: the star formation rate (SFR), stellar mass, AGN luminosity, stellar luminosity, star formation age and the metallicity. Several modules were used in the CIGALE software: Star Forming History module, SSP module, Nebular emission module, Dust attenuation module, Dust emission module, AGN module, Radio and Redshift modules. The quality of the SED fits was measured by a weighted Khi square value.

For the same sample, I have re-fitted these SEDs but without Herschel data points, that's to realize the influence of Far-IR density fluxes on SED fitting and results.

In my third semester, I have studied a sample of hyper-luminous Dust-obscured galaxies (DOGs), recently DOGs shed light on the co-evolution issue, because super massive black holes (SMBHs) in DOGs are expected to be rapidly growing during the co-evolution. DOGs are originally defined as galaxies that are bright in mid-infrared (MIR) while faint in optical (Dey et al. 2008; Fiore et al. 2008).

This sample (18 DOGs) was discovered by (Toba et al. 2015) through combining wide and deep optical images obtained with the Hyper Suprime-Cam on the Subaru Telescope and all-sky mid-IR (MIR) images taken with Wide Field Infrared Survey Explorer with redshift (z~2). This sample in the GAMA 14 hr. field (~ 9 deg^2). The new Herschel point source catalogue data is combined with (i & z) bands, 2MASS, and WISE photometry data, creating spectral energy distributions (SEDs) using CIGALE software.

Description of research in the current semester

In my first project, I have used a very fresh sample of infrared (IR)-bright DOGs is discovered by (Noboriguchi et al. 2019), that are defined as (i-[22])AB ≥ 7.0. By combining ~ 53 deg^2 images of the optical, near-IR, and mid-IR data that are obtained with the Subaru Hyper Suprime Cam (HSC) survey, VISTA VIKING survey, and WISE all-sky survey, respectively, 427 IR-bright DOGs are selected in Noboriguchi's sample. The photometric redshifts were determined in range (1<z<2).

Because of the important of Far-IR for determination of AGN parameters, I have chosen all DOGs which have Herschel SPIRE data points and fitted their SEDs. The SEDs were fitted using CIGALE software. We used the Bruzual and Charlot Simple Stellar Population models (Bruzual & Charlot, 2003), a delayed star formation history with an exponential burst, the Drain and Li model for the dust emission (Draine & Li 2007), and Calzetti model for the attenuation (Calzetti 2000). Moreover, several properties constructed by CIGALE; star formation rate, AGN luminosity, stellar mass and other parameters.

The following figures show one SED for a DOG in our sample (Fig. 1), a map of all DOGs' positions (Fig. 2) and the SRF vs. z (Fig. 3) respectively.

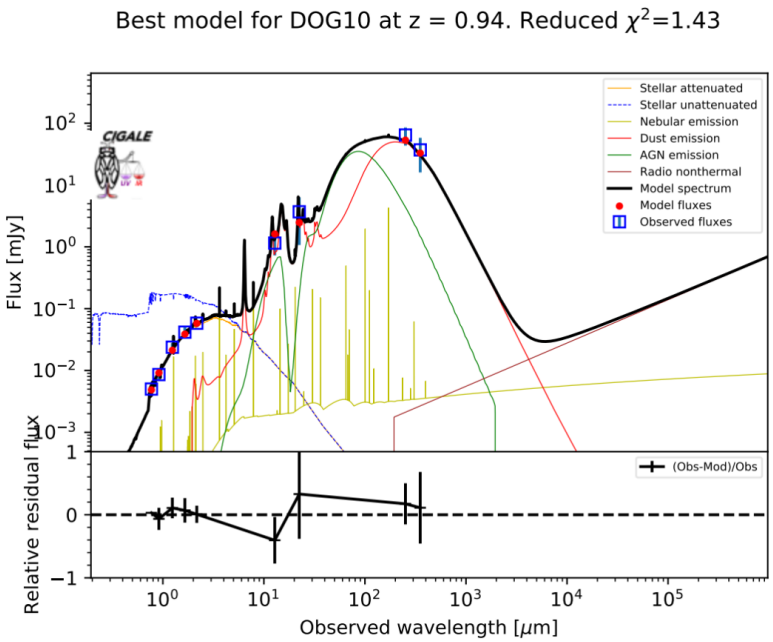

Fig. 1

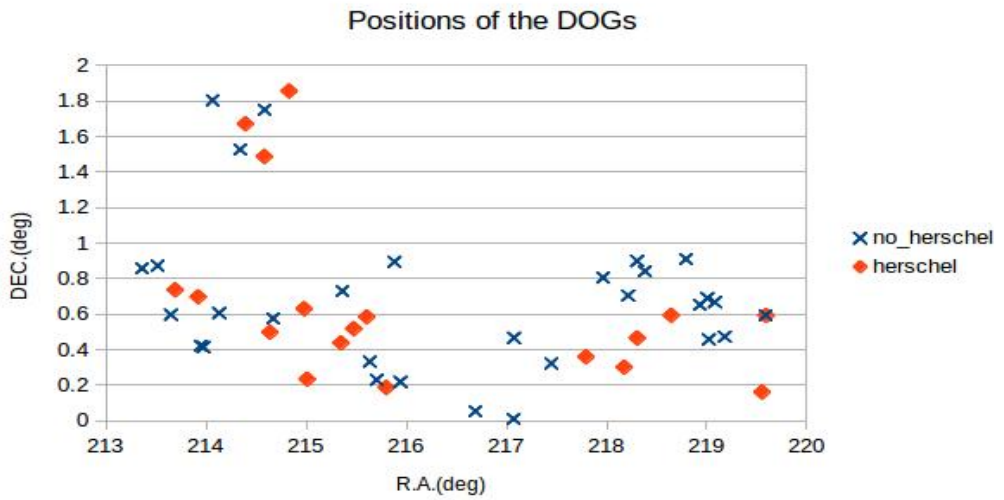

Fig. 2

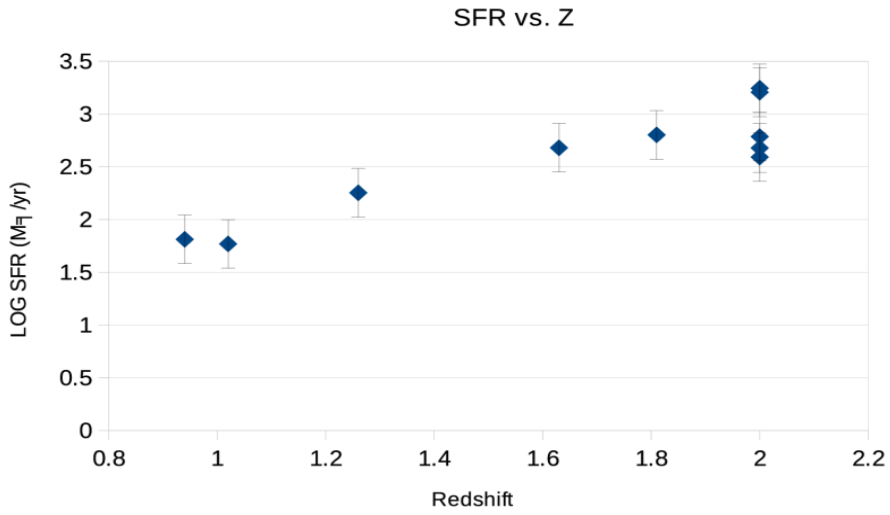

Fig. 3

My second project for this semester was a collaboration with Helga et al. 2019 paper. In this study, new high-resolution HI observations with the Australia Telescope Compact Array (ATCA) are presented towards 4 gamma-ray bursts (GRBs). The interferometric ATCA data was combined with single dish data from the Galactic All Sky Survey (GASS) and derived new Galactic HI column densities towards the GRBs. These new foreground column densities were used to fit the Swift XRT X-ray spectra and calculated new intrinsic hydrogen column density values for the GRB host galaxies. Some almost detections have been seeing of radio point sources at GRB positions by using only a few MHz of the 2 GHz continuum data. To clearly conclude on the detections or non-detections, the full data of the continuum HI line measurements (1-3 GHz) is needed, and that was my mission. I did a radio reduction data for a broad range of the continuum HI line measurements. I have found all density fluxes for all GRBs' fields which have more than 5 sigma detection.

The following table and figure show a part of my results:

Table 1: Some of density fluxes for a number of point sources in GRBs' fields

ID	RA	DC	Peak flux (Jy)	Sigma detection
1838-5729	18:38:25.69	-57:29:22.2	3.029E-0.2	1.037E+01
2050-7815	20:50:59.99	-78:15:53.5	3.396E-0.2	1.537E+01
1956-2636	19:56:49.85	-26:36:32.8	5.556E-0.3	1.405E+0.1
2059-5114	20:59:23.36	51:14:36.1	8.624E-0.2	1.832E+0.1

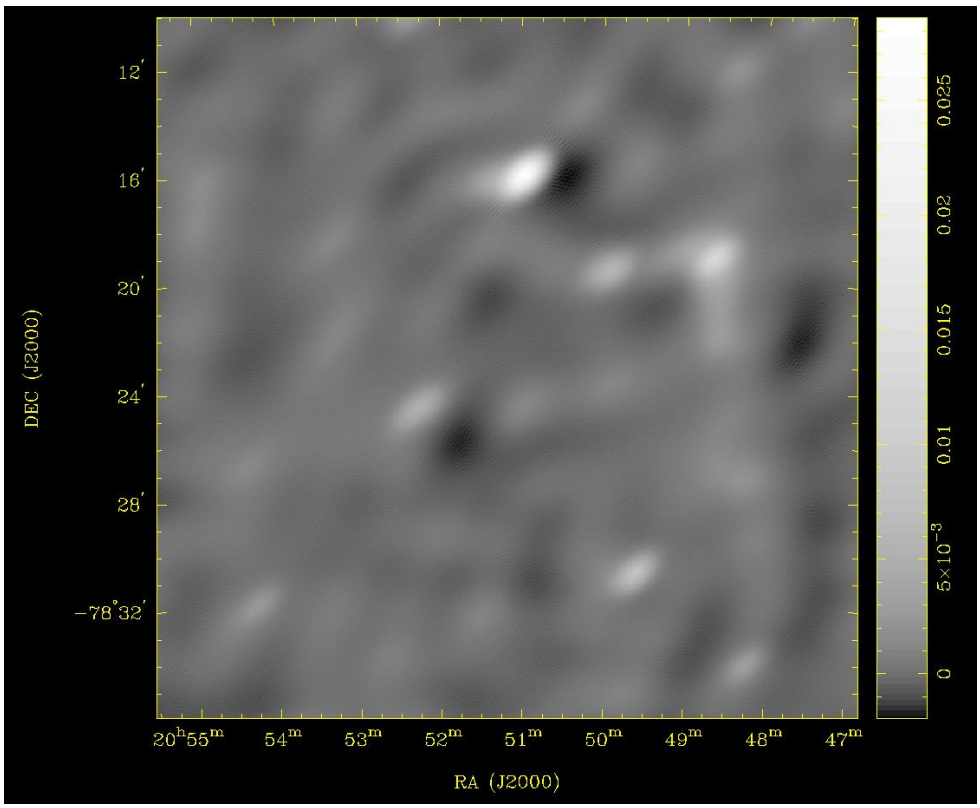

Fig. 4: The clean image of GRB_070508 at 1844 MHz

Publications

- **Suleiman N.**, Al-wardat M., Talafha M., AL-Ameryeen H., Toth V. **(2018)**. Astronomy education in Jordan. Proceedings of the International Astronomical Union, accepted in October 2018.
- **Suleiman N.**, Toth L. V., Kovacs T., Pinter S., Frey S. **(2018)**. AGN parameters in the ELAIS field using CIGALE. Proceedings of the International Astronomical Union, accepted in September 2018.
- H. Dénes, P.A. Jones, L.V. Tóth, S. Zahorecz, B-C. Koo, S. Pinter, I.I. Racz, L.G. Balázs, M.R. Cunningham, Y. Doi, I. Horvath, T. Kovács, T. Onishi, Z. Bagoly, **N. Suleiman (2019).** Exploring the pattern of the Galactic HI foreground of GRBs with the ATCA, minor revision (25-Feb-2019).

Studies in current semester

- FIZ/2/058 – The physics of interstellar matter II – Dr. L. V. Toth
- FIZ/2/119 – Data mining in Astronomy – Dr. Dobos László
- FIZ/KUT-S4 – Guided research work – Dr. Katz Sándor

Conference participations during the doctoral studies

- Attended General Assembly of International Astronomers Union (IAU) in focus meeting 03; Radio Galaxies: Resolving the AGN phenomenon with poster contribution, Aug. 22nd to 23th 2018 at Vienna, Austria.
- Attended General Assembly of International Astronomers Union (IAU) in focus meeting 15; Astronomy for Development with poster contribution, Aug. 28th to 31st 2018 at Vienna, Austria.
- Attended Modern Theories of Gravitation symposium at the Hungarian Academy of Sciences, May 8th 2019, Budapest, Hungary.
- Attended Exploring the IR Universe (the promise of SPICA) with poster Attended, May 19th -23rd 2019, Island of Crete, Greece.
- Attending department and institution seminar, oral contribution, June 6th 2019, Astronomy department at ELTE University, Budapest, Hungary.
- Accepted at Views on the ISM in galaxies in the ALMA era conference as a poster contribution, Sep. 2nd to 6th 2019, Bologna, Italy.
- Appling to Interaction of Stars with their Environment 2019 conference, October 14th to 18th 2019, Budapest, Hungary.

Activities

- *Workshop(s):*
  - Attended Young Astronomers on Galactic Nuclei, October 29th-31st 2018 at ELTE University, Budapest, Hungary.
- *School(s):*
  - Attended the 10th IRAM millimeter interferometry school, October 1st - 05th 2018 at the IRAM headquarters, Grenoble, France.
  - Applied to the 9th IMPRS NeuroCom Summer School which will take place from 16th to19th June 2019 in Leipzig, Germany.

- *Grant(s):*
  - IAU grant to participate the General Assembly, Aug. 20th to 31st 2018 at Vienna, Austria.
  - ELTE Talent Support grant – Budapest, Hungary, Autumn Semester 2018/2019.
  - ELTE Talent Support grant – Budapest, Hungary, Spring Semester 2018/2019.

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