Boletim da Sociedade Astronômica Brasileira, **31**, no. 1, 151-152

The PAH emission characteristics of the starburst-dominated galaxies using Fast Fourier Transform

J. Espinoza[1], Dinalva A. Sales[2], B. Matoso[2], & C. M. Canelo[3]

[1] Instituto Federal de Educação, Ciência e Tecnologia do Rio Grande do Sul, IFRS - Campus Rio Grande, 91501970 - Rio Grande, RS - Brazil e-mail: `jean.espinoza@riogrande.ifrs.edu.br`
[2] Instituto de Matemática, Estatística e Física, Universidade Federal do Rio Grande, Rio Grande 96203-900, Brazil e-mail: `dinalvaires@gmail.com, brendamatoso@live.com`
[3] Departamento de Astronomia, Instituto de Astronomia, Geofísica e Ciências Atmosféricas, Universidade de São Paulo, 05508-090 São Paulo, Brazil e-mail: `camcanelo@gmail.com`

Abstract. A considerable fraction of the carbon in the interstellar medium (ISM), 20% or more, is in the form of polycyclic aromatic hydrocarbons (PAHs). The mid-infrared (MIR) spectra of galactic and extragalactic objects are dominated by strong emission bands at 3.3, 6.2, 7.7, 8.6, 11.3 and, 12.7μm, generally attributed to PAHs and related species. Despite the significant progress made in our understanding of these emission bands, the specifics of their chemical structure and size are unclear mainly in extragalactic source. This lack of detailed knowledge hampers our understanding of the PAH emission bands and their use as a diagnostic tool for probing the physical-chemical conditions of the ionization source of galaxies. We therefore present here a robust methodology to determine physical properties of PAH molecules in a sample of 252 starburst-dominated galaxies taken from Spizer/ATLAS MIR data. We introduce a new method to derive PAH properties of galaxies based on Fast Fourier Transform (FFT) and spatial analysis method (SAM) using theoretical PAH molecules taken from NASA Ames PAH database. PAH species presented in our sample are mostly formed by small molecules, however, we could note that their contribution to the total radiant flux is very low (< 15%). On the other hand, we have small fraction of very larger PAHs in our sample, but they have considerable contribution to the total flux (> 60%).

Resumo. Uma fração considerável do carbono no meio interestelar (ISM), aproximadamente 20% ou mais, está na forma de hidrocarbonetos aromáticos policíclicos (PAHs). Os espectros do infravermelho médio (MIR) de objetos galácticos e extragalácticos são dominados por bandas de emissão fortes a 3.3, 6.2, 7.7, 8.6, 11.3 e 12.7 μm, geralmente atribuídas a PAHs e espécies relacionadas. Apesar do progresso significativo feito em nosso entendimento a cerca dessas bandas de emissão, as especificidades de sua estrutura química e tamanho não são claras principalmente no meio extragaláctico. Essa falta de conhecimento detalhado dificulta nossa compreensão das bandas de emissão de PAH e seu uso como uma ferramenta de diagnóstico para sondar as condições físico-químicas da fonte de ionização de galáxias. Portanto, apresentamos aqui uma metodologia robusta para determinar as propriedades físicas de moléculas PAH em uma amostra de 252 galáxias starbursts derivadas de dados do Projeto Spizer / ATLAS MIR. Introduzimos um novo método para derivar as propriedades de PAH em galáxias com base em Transformada de Fourier (FFT) e método de análise espacial (SAM) usando moléculas teóricas PAHs retiradas da base de dados Ames PAH da NASA. As espécies apresentadas em nossa amostra são em sua maioria formadas por pequenas moléculas, no entanto, podemos notar que sua contribuição para o fluxo radiante total é muito baixa (< 15%). Por outro lado, temos uma pequena fração de PAHs muito grandes em nossa amostra que possuem uma contribuição considerável para o fluxo total (> 60%).

Keywords. galaxies: starburst – infrared: ISM – techniques: spectroscopic

1. Introduction

Polycyclic Aromatic Hydrocarbons (PAHs) represent an effective arrangement to accumulate carbon in the Universe and are the dominant organic material in space (Ehrenfreund et al. 2006). The mid-infrared (MIR) spectra of galaxies either with an active galactic nuclei (AGN) and a Starburst show emission features attributed to PAH molecules, which can be considered to originate in very small amorphous carbon dust grains or very large carbon-rich ring molecules (Puget & Leger, 1989) (Draine & Li, 2001).

The most prominent, well-known PAH emissions are the 6.2μm, 7.7μm, 8.6μm, 11.2μm, and 12.7μm bands (Roche et al. 1991) (Genzel et al. 1998). The differences among the PAH profiles in such astrophysical environments have been attributed, for example, to the local physical conditions and of the PAH's molecule size, charge, geometry, and heterogeneity (Draine & Li, 2001) (Sales et al. 2012).

2. Observation and data analysis

For a better understanding of the PAHs properties in the Universe, Starburst galaxies are the best targets since they carry different burst of young stellar population and, consequently, present strong PAH emission in the MIR spectral wavelengths. We therefore selected objects from the ATLAS MIR starburst-dominated galaxies (MIRSB sample), which is composed of 252 sources observed by Spitzer/Infrared Spectrograph (IRS) previously classified as starburst-dominated by Hernán-Caballero & Hatziminaoglou (2011).

3. Result

In order to derive physical-chemical properties of PAH molecules in our sample we used roughly 700 theoretical PAH species from NASA Ames Database version 2.0 (Boersma et al. 2014). These PAH sample are composed by theoretical molecules with a size range between 6 to 384 carbon atoms and we divide them into 4 classes: (i) very small class are composed by molecules with less than 30 carbon atoms; (ii) small class has

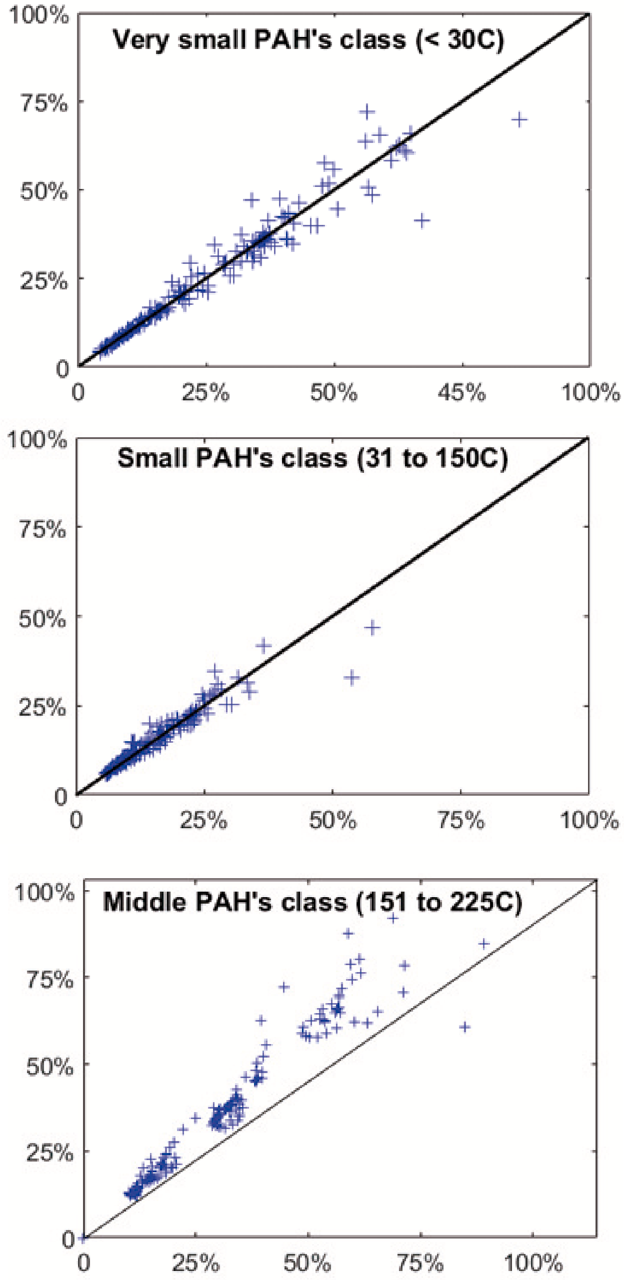

Figure 1. SAM diagrams of our Starburst sample for those 3 PAH's theoretical classes. Solid line are the reference PAH's classes and points are our galaxy sample. Differente classes of PAH molecules are labeled.

between 31 to 150 carbon atoms; (iii) middle class has 151 to 225 carbon atoms; (iv) large class has 226 to 300 carbon atoms and (v) very large has PAHs larger than 300 carbon atoms.

Our methodology requests following steps be applied to galaxy as well as theoretical PAH spectra in order to derive how much each PAH classes contribute to the total flux of a galaxy, which are: (i) to sample spectra of targets; (ii) to average and normalize them; (iii) to measure their covariance matrix; (iv) to apply Fast Fourier Transformation; (v) to derive their eigenvectors and eigenvalues. Once that we have previous information we can compare observed galaxy spectra with theoretical PAH classes using spectral angle mapping (SAM) technique (see Fig. 1 and 2).

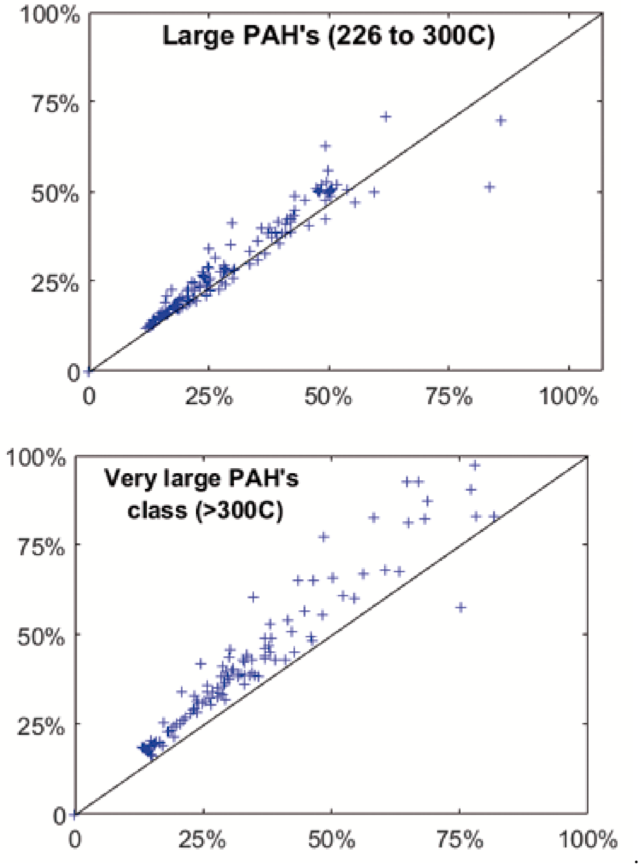

Figure 2. The same as previous figure to large (226 to 300C) and very large (> 300C) PAH's classes.

4. Summary And Conclusions

From results showed in Fig. 1 and 2 we can conclude that it was possible to infer physicalchemical properties of the PAH molecules of 252 Starburst dominated galaxies with proposed new robust methodology. PAH species presented in our sample are mostly formed by small molecules, however, we could note that their contribution to the total radiant flux is very low (< 15%). On the other hand, we have small fraction of larger PAHs in our sample, but they have large contribution to the total flux (> 60%). This study is in progress and we will investigate how PAH's properties change with galaxy's activity.

References

Boersma et al. 2014, ApJSS, 211, 8.
Ehrenfreund et al., 2006, 6, 490.
Draine & Li 2001, ApJ, 551, 807
Genzel et al. 1998, ApJ, 498, 579
Hernán-Caballero & Hatziminaoglou, 2011, MNRAS, 414, 500
Puget & Leger, 1989, ARA&A, 27, 161
Roche et al. 1991, MNRAS, 248, 606
Sales et al. 2012, MNRAS, 429, 2634