Big Data Analysis

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2 Participants

2.1 ICRANet participants

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2.2 Ongoing collaborations

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3 Description

The current situation in astrophysics allows to use large archival astrophysical data from infrared, optical and very high energetic radiations. This new situation allows to study a single source in a multi-wavelength context, and permits to obtain more information on the physical mechanisms behind the observed radiation. But, following the Galileian principle, before the phase of "theoretical inference", the interpretation of data comes first, as well as the phase of data reduction and analysis. The advent of new and more powerful calculators and programming languages have largely improved the first step of the data reduction, allowing semi-automatization procedures for data acquiring and storing. But behind each of these procedures, as well as techniques for their interpretation, there is a human mind.

Recently we have started and developed a program involving the use of already existing software packages for space data reduction, as Swift, Fermi, XMM and HST, and on-ground facilities as optical telescopes at ESO and Canary Island. New collaborations started, about the study of optical transients, as well for the analysis in real-time of high-energy sources as GRBs. In the following, we will provide a more detailed description of the on-going activity for each treated argument.

3.1 Multi-wavelength analysis of GRBs

The possibility of surveying the entire sky with the new generation of optical telescopes allows to match catalogs the large list of transients discovered with these surveys with catalogs of higher energetic astrophysical sources. A large fraction of these optical transients remains unclassified, and for this reason they could be related to other than the well-known galactic explosions, as cataclysmic variables, or extra-galactics ones, like supernovae. Beyond the spatial coincidence, astrophysics suggests that a particular time constraint must be taken into account in order to associate an optical transient with an high energetic source, as it can be a gamma ray burst (GRB). A first approach was developed, using the entire Asiago and Harvard catalog of known SNe Ia matched with the Fermi Gamma-ray Burst Monitor (GBM) log burst catalog [1]. Interestingly, all the candidates are nearby supernovae, but only in one case the association is strong, so that it was proposed for the first time a new nearby GRB-SN association in the case of GRB 120121B/SN 2012ba ($z = 0.017$). Consequently, also the rate of nearby GRBs provided by the Fermi

GBM was inferred and found to be in agreement with other rates presented in literature.

Further applications of this catalog-matching technique (well-known in Big Data Analysis) will be developed, with particular refereeing to very large optical surveys and next generation of multi-wavelength detectors. This method will complement the search for counterparts of any astrophysical source and consequently obtaining precious physical information on their observed evolution.

3.2 Analysis of nova outbursts

The recent discovery of very high energy radiation in galactic novae, the possibility of investigating with large details the soft X-ray emission observed after the ejecta transparency, and the availability of high-resolution optical and near-infrared spectrographs represent a new set of instruments for investigating and shed the definite light on these astrophysical explosions. The evidences for a-sphericity in nova ejecta are still an enigma, particularly the physical mechanism beyond this evidence, which seems to act in different way for different novae. Moreover, photons with energy radiation larger than 100 MeV observed in five novae, from the launch of the Fermi satellite, can provide further constraints and at the same time additional information on the physical mechanisms acting in novae phenomenon.

The study of one of the most famous recurrent novae, T Pyx, and the outburst of one of the most luminous novae in recent years, V 1369 Cen, was considered and, in the case of V 1369 Cen, the analysis is still on-going. Time at large telescopes, as the 3.6 meters Telescopio Nazionale Galileo, the ESO/MPG 2.2 meters and 0.6 meters of the Pontificia Universitade Catolica de Chile was obtained for the study of these two novae. High-resolution spectra were obtained using these telescopes, and they allowed several information for these novae as :

- the evidence of an hybrid spectral transition in T Pyx, which was first presented few months after its outburst at the international Palermo meeting in 2011 [2];
- further analysis on the T Pyx binary system, inferred from the nebular spectra and Swift X-ray observations, with the evidence of asphericity in the nova ejecta [3];
- the first analysis of the V 1369 Cen, obtained using the PUCHEROS instrument of the Pontificia Observatory [4];
- other interesting results for V 1369 Cen which will be presented soon in two publications (in preparation).

From these analysis, it would be possible to obtain information about the composition of the nova ejecta (from the nebular spectra analysis), the study of the nova evolution and information about the expanding systems and geometry (from evolution of P-Cyg absorption lines), the first detailed analysis of narrow absorptions, detected in V 1369 Cen, but more important, to provide a first high-resolution database for novae, in collaboration with a network of scientists all around the world. Since novae are supposed to be one of the first "farm" of metals in our Galaxy, the continuous monitoring of novae in outburst will continue for next years.

3.3 Support to the Swift and future space missions

The collaboration with lead teams in space astrophysics is vital for the entire astrophysical research. Moreover, it is a very good chance to learn with large details all the mechanisms that lie beyond the procedure of data reduction and analysis of space instruments, as it is the case of the Swift satellite. Recently we join the Swift group, providing human time and "know-how" for the monitoring and real-time analysis of data obtained with the Burst Alert Telescope (BAT) and in particular the X-Ray Telescope (XRT). Every month, about five days are dedicated to the continuous monitor of new GRBs and high energetic transients that trigger the Swift-BAT detector and then followed-up by the XRT.

Moreover, in the last two years we join the LOFT community, providing simulations for the Wide Field Monitor instrument which will be dedicated completely to survey the energy range (2 – 50) keV, to catch photons emitted by GRBs. We are working on one of the most interesting bursts known, GRB 060218, for which we simulate the signal that the LOFT-WFM would have observed form this source [5]. Since the WFM is more sensitive than the BAT, we will have more information on such similar low energetic and nearby GRBs, which recent analysis suggest to be more numerous than the ones observed by the Swift-BAT.

3.4 Other activities

Other external collaborations were developed, particularly related to the know-how in data reduction of X-ray detectors (Swift-XRT, XMM, HST) and analysis of optical spectra. Indeed, two works regarding the analysis of optical data obtained with the Hubble Space Telescope (HST) and archival data of lensed systems were accepted and in publications on scientific journals [6,7].

Support to the ICRANet *compact objects* group is still provided : after the analysis and study of the emission from soft gamma repeaters (SGR) and anomalous X-ray pulsars (AXP) [8,9], we are collaborating in the data re-

duction and analysis of data from X-ray binary pulsars and magnetic with dwarfs.

Finally, continuous support and collaborations with the *grb1* group is one of the priority. The analysis in almost real-time of GRB X-ray afterglow light curves and their possible interest in cosmology, and the data analysis of possible IGC candidates from the identification of different episodes in GRB prompt emission light curves is one of the most important activities of the group since it allows to identify possible candidates of IGC binary-driven hyper novae [10,11,12] and then study with very large details and also follow their evolution in real-time, particularly for nearby sources.

Last, but not the least, the presence at public events was initiated with the national day of the research, with two main events in the last two years in Pescara. The possibility of presenting recent results in astrophysics, and also discuss of astronomy with people, is one way for the sensitization of the public opinion to the fundamental role of the astrophysical research in the human history.

4 Publications

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3. Izzo, L.; Della Valle, M.; Ederoclite, A.; Henze, M.; *On the 2011 outburst of the Recurrent Nova T Pyxidis*, (2014) in publication in Acta Politechnica, arXiv:1407.7076;

4. Izzo, L.; Mason, E.; Vanzi, L.; Fernandez, J. M.; Espinoza, N.; Helminiak, K.; Della Valle, M.; (2013), ATEL 5639;

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6. Diego, Jose M.; Broadhurst, T.; Benitez, N.; Umetsu, K.; Coe, D.; Sendra, I.; Sereno, M.; Izzo, L.; Covone, G.; *A Free-Form Lensing Grid Solution for A1689 with New Mutiple Images*, (2014), accepted for publication in Monthly Notices of the Royal Astronomical Society, arXiv:1402.4170;

7. Cao, Shuo; Covone, Giovanni; Jullo, Eric; Richard, Johan; Izzo, Luca; Zhu, Zong-Hong; *Source plane reconstruction of the giant gravitational arc in Abell 2667: a candidate Wolf-Rayet galaxy at $z\sim1$*, (2014), accepted for publication in The Astronomical Journal, arXiv:1410.6594;

8. Boshkayev, K.; Izzo, L.; Rueda Hernandez, J. A.; Ruffini, R.; *SGR 0418+5729, Swift J1822.3-1606, and 1E 2259+586 as massive, fast-rotating, highly magnetized white dwarfs*, (2013), A&A, 555, 151;

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11. Ruffini, R.; Izzo, L.; Muccino, M.; Rueda, Jorge A.; Barbarino, C.; Bianco, C. L.; Dereli, H.; Enderli, M.; Penacchioni, A. V.; Pisani, G. B.; Wang, Y.; textitInduced Gravitational Collapse in the BATSE era: the case of GRB 970828, (2013) accepted for publication in Astronomy Reports, arXiv:1311.7432;

12. Ruffini, R.; Muccino, M.; Bianco, C. L.; Enderli, M.; Izzo, L.; Kovacevic, M.; Penacchioni, A. V.; Pisani, G. B.; Rueda, J. A.; Wang, Y.; *On binary-driven hypernovae and their nested late X-ray emission*, (2014), A&A, 565, 10.