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Study of high-z Universe with Gaia and LDS Photographic Sky Surveys

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We report here on possibilities of study of high z Universe with ESA Gaia satellite and photographic sky surveys with low dispersive spectroscopy.

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1. Introduction

The low dispersive spectroscopy (LDS) was widely used in the past in numerous photographic sky surveys with objective prism (Robbins and Osborn, 2009, Hudec and Hudec, 2013). Nowaday, ESA Gaia satellite provides fraction of its outputs as ultra low dispersive spectra.

2. ESA Gaia satellite

The ESA Gaia satellite (e.g. Prusti, 2012) is designed to provide astrometry (V $\leq$ 20): completeness to 20 mag (on-board detection) with accuracy of 25 microarcsec at 15 mag (Hipparcos: 1 milliarcsec at 9 mag). Gaia is scanning satellite, with two viewing directions (http://sci.esa.int/gaia/).

Photometry (V $\leq$ 20) is performed as well for astrophysical diagnostics (low-dispersion photometry) + chromaticity. Fraction of data is delivered as ultra low dispersive spectroscopy (BP and RB photometers).

2.1 The astrophysical strength of Gaia

The motivation is performing astrophysics with Gaia data. The photometric sampling provided by Gaia will not be (for many astrophysical sources) optimal. However, the fine spectro–photometry (in reality ultra low resolution spectroscopy) provided by BP/RP photometers will be unique and important for many astrophysical investigations with Gaia, including Gamma – Ray Bursts (GRB) science.

2.2 Gaia and GRBs: Photometry

The Optical Transients (OTs) and Optical Afterglows (OAs) of GRBs can be recognized according to their characteristic power–law fading profile, but a sequence of observations is necessary. However, the sampling provided by Gaia is not optimal, hence only very rarely we can expect detection of OT of GRB based only on this type of data. Additional data can be provided by ground–based robotic telescopes (RT). This is a goal within Supplementary SOS Observations workpackage (WP) in Gaia CU7 unit.

2.3 Gaia GRB detection

Proposed strategy for observations of OAs with Gaia is as follows: Most OAs form an ensemble with very similar color indices largely independent on the phase of the decaying curve for the initial 10 days after GRB and for redshift z $\leq$ 3.5 (Simon et al., 2004).

2.4 Gaia and GRBs: Spectro–Photometry

The primary strength of Gaia for GRB study is the fine spectro-photometry. The OAs of GRBs are known to exhibit quite typical colors, distinguishing them from other types of astrophysical objects (Simon et al. 2004), Hence a classification of OTs of GRBs in one photometric shot will be possible. This approach is important also for other types of High Energy Sources.

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2.5 Gaia and GRBs: LDS (Low Dispersion Spectroscopy)

Part of Gaia data will be delivered as ultra-low dispersion spectra (BP/RP). This is unique output from astronomical space mission. What will be the value of Gaia LDS for science of GRBs? Astrophysics with Ultra LDS provided by Gaia RP/BP is as follows: Continuum profiles including high z objects, Strong emission lines, Strong variable emission lines, Prominent spectral variability, Possibility of spectroscopic Gaia alerts, Follow-Up by ground based RTs with LDS, Plate Sky Surveys can serve as real LDS simulator, LDS of distant GRBs (adopted from QSOs), LDS of OAs of GRBs with Strong Intervening Absorbers, and LDS and Highly Redshifted Universe.

The redshifted Lyman alpha line/break can be used to measure the redshift. This was e.g. the idea of JANUS Space Mission: 0.7–1.7 microns (Gaia RP 0.65–1.0). The digitized plate surveys can be used as well especially those taken in red-IR (there are numerous surveys in that regions taken in the past for red objects like carbon stars etc)

2.6 The estimated Gaia GRB detection rate

The estimated Gaia detection rate for OTs and OAs of GRBs, including orphans, is $\sim$ few to $\sim$ 100 in the whole Gaia lifetime (5 years). This low rate is due to small FOV of the Gaia telescopes ($\sim$ 0.36 deg2 each). Higher detection rate in plate LDS surveys (due to much larger FOV) in which analogous strategies (e.g. high-z triggers) can be applied.

2.7 Gamma Ray Bursts and Astronomical Plates

GRBs investigation on Astronomical Survey Plates can be as follows: (i) Searches based on unique GRB optical LC, (ii) Searches based on unique GRB color, and (iii) Searches based on LDS spectroscopy (for highly redshifted GRBs)

The motivation is that the Photographic Sky Surveys have so large coverage that each sky positon is covered for years of continuous monitoring (Hudec, 1999 and 2007). There is huge amount of data with more than 7 million sky exposures each covering typically 100 sq.deg down to mag 16 or even deeper. Hence OTs and OAs of GRBs are expected to be recorded at times of their maxima. Orphan OAs can be also detected.

2.8 Astrophysics with LDS in the past

The most important LDS Plate Surveys/Databases for GRBs study are as follows. German La Paz Bolivia Expedition: Southern Sky Coverage D, Hamburg Quasar Spectral Survey D, Digitized Byurakan Spectral Survey D, Northern Halpha MtWilson-Michigan Sky Survey PD, and Southern Halpha MtWilson-Michigan Sky Survey PD, where D = Digitised, PD = Partly Digitised.

Note that the LDS photographic plates can go more than 100 years back in time and that there are also LDS Plate Surveys in the IR.

Notable is the recent Bamberg GRB Project in which 5000 selected high-quality photographic sky patrol plates were investigated for flaring GRB/OT candidates (including orphans). In total nearly 50 000 square degrees covered for more than 24 hrs, with lim mag 15-16. In the study, 6 candidates were found, 2 of them promising, namely quiet candidates consistent with GRB host galaxy. This study was Award-winning in German High School Competition Jugend Forscht in 2012 (Hudec et al., 2013).

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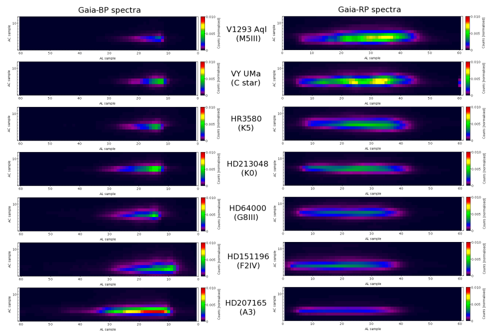

Figure 1: Example of ultra low dispersive spectra provided by Gaia BP and RP photometers. A pair of red and blue spectra is shown here for each of the seven stars. The plot is arranged with cool stars (approximately 3000 C) at the top, to hotter stars (around 8000 C) at the bottom. As expected, the hottest stars are relatively stronger in Gaia's blue photometer, and weaker in the red photometer. Conversely, the cooler stars are brighter in the red photometer (http://blogs.esa.int/gaia/2014/06/05/gaia-takes-science-measurements/).

3. Conclusions

Gaia offers unique chance to provide early or simultaneous LDS for GRBs (so far LDS for GRBs is provided mostly late), to recognize/classify OAs and OTs of GRBs using LDS and/or color information, to detect/study orphan OAs of GRBs, and also redshift estimation up to z $\sim$ 7. The digitized LDS sky survey plates have analogous use.

4. Acknowledgements

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