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Catch the Biggest Ones: Slitless Spectroscopy of Extragalactic Objects

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Abstract. Despite the great progress made in the last decade, the study of very massive stars remains hampered by the lack of statistics and only a few hundred stars with $M_{init} \geq 30\ M_\odot$ are known in our Galaxy. Low resolution, slitless spectral images were obtained at the Loiano Observatory in the wavelength window 3300–6420 Å, in order to identify in extragalactic objects targets displaying the most prominent features that characterise the spectrum of bright hot stars, WR and Luminous Blue Variables (LBV), and of nebular regions as well. We present the results with the well studied galaxy M 101, where the previously known H II regions with WR star signatures are easily identified.

Polcaro & Viotti (1998) proposed at the ADASS VII Conference a simple slitless spectroscopic method that was effectively employed in the search of very massive stars, as well as in the identification of the optical counterparts of galactic X–ray sources (see e.g. Bernabei & Polcaro 2001a,b; Israel et al. 1999). In this regard, despite of the great progress made in the last decade, the study of the very massive stars remains hampered by the lack of statistics and only a few hundred stars with $M_{init} \geq 30\ M_\odot$ are known in our Galaxy. Actually, being short–living objects, the known very massive stars are associated with regions of large interstellar extinction, hence they are not easy to identify in our Galaxy. In fact, many the known objects of this category have been found in external galaxies and in the Magellanic Clouds. For instance, only one half of the LBVs known to date are Galactic objects. On the other hand, the new generation of optical telescopes makes the spectroscopy of bright extragalactic stars a relatively easy job: therefore, we can hope to increase our knowledge of very massive objects from the study of this class of stars in nearby external galaxies seen 'face–on', that is with a little interstellar matter interposed. However, the problem arises in the preliminary identification of the targets: very massive stars are difficult to identify on the base of photometric surveys alone, being their colours strongly affected by local and circumstellar reddening. Unfortunately, the method that we have employed to date for the search of galactic objects, is scarcely useful, being based on a combination of filters and grisms, suitable only for relatively bright objects (our sensitivity limits is of the order of V≈14).

Because of these reasons, we developed a new slitless procedure, allowing the spectroscopic survey of a relatively wide sky region on a single image, using

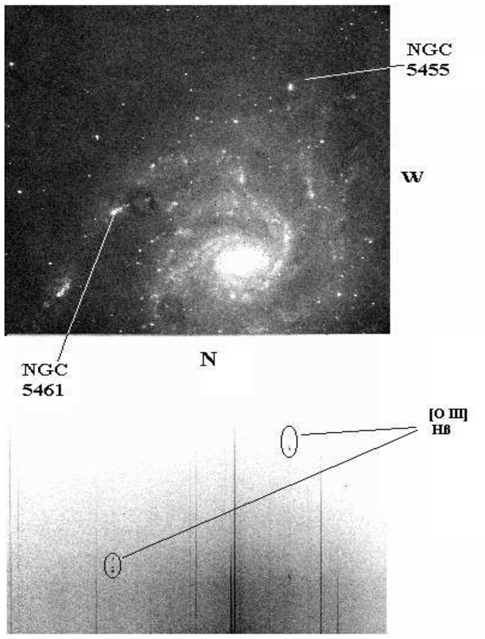

Figure 1. Unfiltered image of M 101 (top) and the related slitless spectral image (bottom). Wavelengths increase from top to bottom. The two bright H II regions NGC 5455 and NGC 5461 are clearly identified by the Hβ and [O III] lines.

the current observatory's instrumental set–up. As a test of the procedure we have obtained a slitless image of a 13×13 arcmin^2 region around the well studied galaxy M 101 using the Loiano Observatory 1.52 cm telescope equipped with the Bologna Faint Objects Spectrometer and Camera (BFOSC, Gualandi & Merighi 2001), and an EEV D129915 CCD (1300×1340 pixels).

A grism (no.3, with a resolution of 5.5 Å) selects a wavelength window (nominal bandpass: 3300–6420 Å) centred near Hβ, where the most characteristic spectral features of bright hot stars, Wolf–Rayet stars and Luminous Blue Variables (LBV) are present, as well as those of nebular H II regions and AGN's. The BFOSC unfiltered image of M 101 is shown on the top of Fig. 1, and on the bottom the corresponding 60 sec slitless spectral image, with the central wavelength (about 4900 Å) coincident with the stellar image, so that the target identification of the 'strips' in the spectral image is straightforward. Notice that

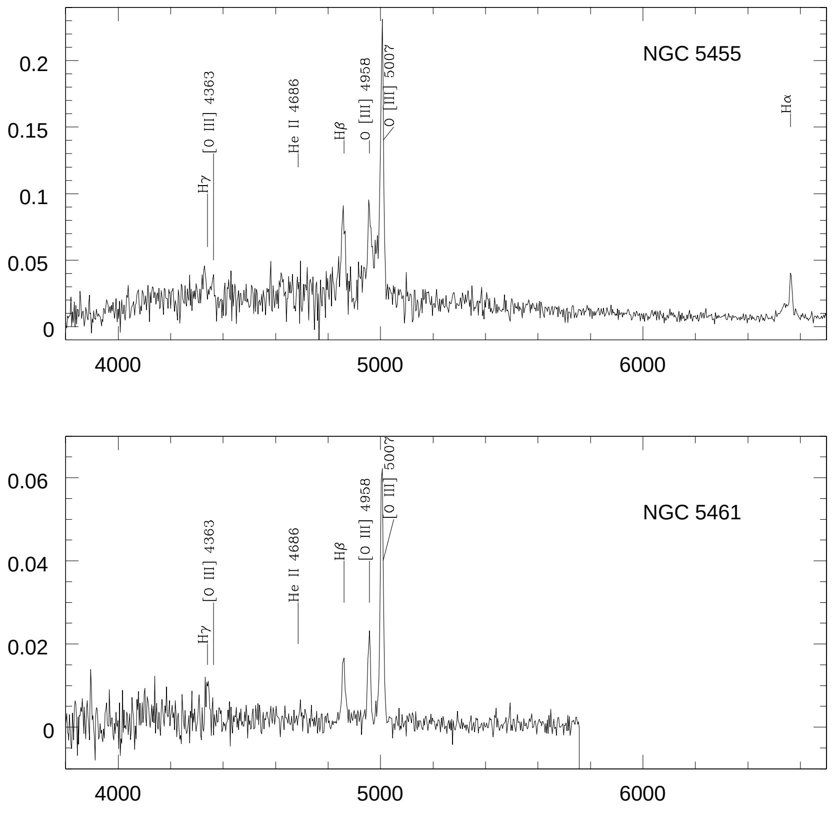

Figure 2. Tracings of the spectrum of the H II regions in M 101: NGC 5455 (top) and NGC 5461 (bottom). The main spectral features are marked.

the actual recorded wavelength range depends on the y–position (i.e. declination) of the object in the field. Hence, the Hα region could be present in the spectra of the objects sited in the upper part of the field (e.g. NGC 5455) but is absent in the more northern objects, as it is the case of NGC 5461. The 60 sec spectral image of M 101 (bottom of Fig. 1) shows many 'spectral strips' corresponding to different regions of M 101, the most intense ones are the central core of the galaxy, a compact region ~7 arcmin to the SE, and two H II regions SW and SE of M 101: NGC 5455 and NCG 5461. The extracted spectra of the two H II regions are shown in Fig. 2 in order to illustrate the data quality that can be obtained from this procedure also with a short exposure time. They are characterized by strong nebular emission lines of hydrogen (Hα, Hβ, Hγ), and of [O III] (5007, 4959 and 4363 Å). The Hβ–[O III] signature of the two regions is easily seen in the spectral image. In principle, these lines together with the 4640–4686 Å feature, can be used for a quick–look identification of emission–line objects in the field, such as Of, WR, LBV stars, and compact H II regions (e.g., D'Odorico et al. 1983). Diffuse emission is also present in the spectrum of NGC 5455, probably from extended diffuse nebulosity, but the very short exposure time does not allow a more detailed analysis of this feature.

Finally, we recall that this method not only permits the object identification in the field, but also an accurate spectrophotometric investigation of the many objects present in the image, by using photometric standards in the same or in a nearby field. This will be the next step of our work.

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