STELLAR ACTIVITY AT FUV/RADIO WAVELENGTHS

M. LEITZINGER\textsuperscript{1}, P. ODERT\textsuperscript{1}, A. HANSLMEIER\textsuperscript{1},
I. RIBAS\textsuperscript{2}, A.A. KONOVALENKO\textsuperscript{3}, M. VANKO\textsuperscript{4},
H. LAMMER\textsuperscript{5}, M.L. KHODACHENKO\textsuperscript{5} and H.O. RUCKER\textsuperscript{5}

\textsuperscript{1}Institute of Physics, IGAM, Karl-Franzens University, Universitätsplatz 5, 8010 Graz, Austria,
\textsuperscript{2}Institut d’Estudis Espacials de Catalunya/CSIC, Campus UAB, Facultat de Ciencies, Torre C-5 -parell-2a planta, E-08193 Bellaterra, Spain
\textsuperscript{3}Institute of Radio Astronomy, Ukrainian Academy of Sciences, Chervonoprapornya 4, 61002 Kharkov, Ukraine
\textsuperscript{4}Astrophysikalisches Institut und Universitäts-Sternwarte, Schillergäßchen 2-3, 07745 Jena, Germany
\textsuperscript{5}Space Research Institute, Austrian Academy of Sciences, Schmiedlstrasse 6, Austria

Abstract. Since stellar activity affects atmospheres of close-in habitable exoplanets, knowledge of a star’s activity level is crucial. Different wavelength ranges yield different possibilities on investigating stellar activity phenomena such as flares and CMEs. We present two approaches to this topic using observations from the FUV and Radio domains. The FUV provides density sensitive line ratios, which show enhancements during stellar flaring. The second approach is dedicated to the decameter wavelength domain, where we use the known correlation between radio decameter type II bursts and CMEs on the Sun. We present promising events on the active M-dwarf AD Leo which show a high probability of being of stellar origin concerning the applied criteria for discriminating between stellar and artificial emission. The detected bursts have parameters similar to solar decameter type III bursts. We present and discuss results of both approaches.

Key words: stellar activity - stellar flares - late-type stars

1. Introduction

Since planetary atmospheres are exposed to high energy X-ray and EUV radiation as well as to high energetic particle impacts in form of high velocity mass expulsions, we search for signatures of such phenomena on selected stars. The main target of this study is the active M star AD Leonis. This dwarf star is known to be a promising target for stellar activity investigations. One of the rare detections in literature of mass motions on stars was
found on AD Leo (Houdebine et al., 1990). We use on-line available FUSE (Far Ultraviolet Spectroscopic Explorer) data to search for flares and also for signatures of mass motions in the atmosphere of AD Leo.

In the second approach we search for decameter type II bursts in dynamic spectra obtained from World’s largest decameter array the UTR-2 (Ukrainian T-shaped Radio telescope - 2nd modification), which are known to be correlated to shock waves driven by CMEs on the Sun. We present results of both studies.

2. Observations

We retrieved the FUSE data set A022010 (AD Leo) from MAST (Multi Archive at Space Telescope) and extract calibrated spectra and intermediate data files from the raw data files using CalFuse v3.1.3. The data set consists of 41 spectra and covers an observing time of 65.1 ks. Since AD Leo was observed in time tagged mode, both, spectra and light curves are available.

The radio data were obtained from the first session of active stars observations at the UTR-2 (02.-12.02.2007). The session results in 10 nights or about 60 hours of decametric observations and one night of coordinated photometry (Tatranska Lomnica/Slovakia) of AD Leo.

3. Results in the Radio Domain

A visual inspection of the radio data showed that more than ten events have a high probability of being of stellar origin, according to our criteria. We distinguish between signals from the main and the side lobes and use a second digital spectrometer (installed on beam five) for investigations of the stars background. If a signal is detected in the main lobe and is absent in the side lobes as well as in the main and side lobes of beam 5, we investigate the event in detail. The UTR-2 provides such a multi-beam capability for up to five simultaneously operating beams. The decameter wavelength range suffers from severe pollution of man-made RFI (radio broadcasting etc.) as well as from ionospheric disturbances, such as scintillations. To be sure not to assign scintillation structures to stellar origin, we analyse also the calibration spectra of a well known source recorded every day before the main observations. If we see similar structures in the calibration spectra as
well as in the stellar spectra we discard them from further analysis. The possible stellar events are fast drifting bursts (cf. Figure 1) showing a mean drift rate of 1-2MHz/s and lifetimes of some to 20s. The orientation of the events shows no preference.

Figure 1: Shown are two (No. 47 and 167) potential stellar events which are indicated by black arrows. The first column are dynamic spectra including information from the main and the side lobes. The second column shows dynamic spectra from the side lobes, and the third column shows dynamic spectra from the background. The images are scaled from minimum (black) to maximum (white), all dynamic spectra are averaged with a factor 4, in frequency and time.
4. Results in the FUV Domain

The light curve analysis of the AD Leo data shows two distinct flares, which have been already reported by (Christian et al., 2006). A computation of the CIII\textsubscript{1176}/CIII\textsubscript{977} line ratio showed a clear maximum during flaring. An additional study of solar disk-integrated TIMED (Thermosphere Ionosphere Mesosphere Energetics and Dynamics) and SORCE (Solar Radiation and Climate Experiment) spectra showed the same behaviour on the sun. The corresponding FUSE spectra show an overall enhancement, in the transition region line OVI\textsubscript{1032} red wing enhancements are detected, and no obvious Doppler shifts are detected. An investigation of the FWHM of all OVI\textsubscript{1032} profiles, showed a maximum at spectrum No. 38 which is one spectrum after the flare spectrum No. 37. A closer inspection shows a distinct blue wing enhancement, with a shift of 90-100 km/s (cf. Figure 2).
5. Discussion

Both approaches have the same goal, namely the detection of signatures of stellar mass motions. We could not detect decameter type II bursts in the radio data, but type III like events, which were never seen before in stellar dynamic spectra at these wavelengths. Due to a bad weather situation we only had one night of optical photometry, which shows a distinct flare. The corresponding dynamic spectra show now variation.

The deduced velocity of the detected blue wing enhancement in the FUSE data is low. A possible explanation could be maxima of solar quiescent coronal plasma motions which show the same velocity as well as “broad components” detected on AU Mic, a M0 type star, by Linsky and Wood (1994) as broadened CVI\textsubscript{1548} profiles. Another approach could be the possibility of a projected shock wave. OVI\textsubscript{1032} profiles of bright regions in the Cygnus Loop Super Nova Remnant (Blair et al., 2002) show very similar profiles with the same blue wing enhancement and the same Doppler velocity. Also UVCS (Ultraviolet Coronagraph Spectrometer on board SOHO) observations (Ciaravella et al., 2005) of shock waves driven by CMEs have shown such features, but with a much broader enhancement.

Acknowledgements

M.L., P.O. and A.H. gratefully acknowledge the Austrian Fonds zur Förderung der wissenschaftlichen Forschung (FWF grant P19446) for supporting this project.

References
