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Magnetic activity and solar-like pulsations of X-ray sources in the *Kepler* field of view

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Abstract. We report on cross-matching the ROSAT All-Sky Survey and the XMM-Newton catalogs with the *Kepler* Input Catalog (KIC). For several stars associated with X-ray sources, we provide also an access to our high-resolution spectroscopic observations.

Keywords. stars: activity - star-spots, X-rays: stars

1. Magnetic activity and solar-like oscillations of cool stars

Solar-like magnetic activity is a widespread phenomenon among cool stars. The most evident effect on the stellar photospheres are star-spots which are tracers of the magnetic flux tube emersion from the sub-photospheric convective layer. The spots convey information about the stellar rotation and photospheric motions, such as the latitudinal drift of spots along the activity cycle and the differential rotation. These, together with the convection, are basic ingredients of the dynamo mechanism for the magnetic field intensification.

The convective motions themselves are responsible for the excitation of solar-like oscillations in the cool stars (Christensen-Dalsgaard 2004). In the same time, though, the magnetic field quenches the amplitude of those oscillations (Karak & Choudhuri 2012). Therefore, it is very interesting to study the trade-off between these two physical phenomena which are also closely related to our ability to derive the basic physical parameters of cool stars.

A successful attempt to study the magnetic activity and differential rotation of three *Kepler* targets, KIC 8429280, 7985370, and 7765135, was made by Frasca *et al.* (2011) and Fröhlich *et al.* (2012). An interesting point of the study by Frasca *et al.* (2011) is that the solar-like oscillations are not visible in the power spectrum of the *Kepler* 1-min-long cadence time series of KIC 8429280†. That indicates that either the convective zone of that star excites oscillations of tiny amplitude or that a very strong magnetic field suppresses the pulsations.

Most of the active stars in the *Kepler* field have not been examined so carefully, though. That concerns in particular the fainter stars associated with X-ray sources. Therefore, in order to facilitate the study of active stars in the *Kepler* field, we made use of the fact that the active stars can be best selected on the basis of their coronal X-ray emission

† For the spot-modelling, the *Kepler* 30-min-long cadence of observations are sufficient. However, for the search of the solar-like oscillations, the 1-min-long cadence is needed.

Table 1. The first and the last line, and the first nine of the 13 columns of the catalog cross-matching RASS and KIC.

RASS number	α_{2000} RASS	δ_{2000} RASS	Counts RASS	r [arcsec]	KIC number	α_{2000} KIC	δ_{2000} KIC	kepmag KIC
J183355.9+514313	278.48291	+51.72028	2.41e+00	4.296	12631873	278.482390	+51.719131	9.590
.....	.....	.....	.....	.....	.....	.....	.....	.....
J195307.2+402714	298.28000	+40.45389	6.09e-02	19.704	5301903	298.280400	+40.448425	19.034

and we cross-matched the RASS (Voges *et al.* 1999) and XMM-Newton (2010) catalogues with the KIC (2009) catalogue. Taking into account different spatial resolution of the XMM-Newton and the RASS, we considered a *Kepler* star to be likely associated with the X-ray source if it is found within 10 arc sec from the position of the nearby XMM source or 20 arc sec from the RASS source. We found 297 XMM sources falling into the *Kepler* field of view and 587 KIC objects (for the completeness, we count all the entries, i.e., stars and galaxies) likely associated with them. For the RASS, the respective numbers are 127 and 566. That result means that most of the X-ray sources have optical counterparts which have one or more close neighbours, sometimes relatively bright. That creates two problems: First, it is hard to decide which of those stars is the X-ray source. Second, the *Kepler* observations may be contaminated by the nearby star(s).

Our catalogs of the cross-matched sources are available online†. In Table 1, we provide the first and the last line and the first nine columns of the cross-match between the RASS and the KIC catalogues; the cross-match between the XMM-Newton and the KIC catalogues looks analogous.

2. Ground-based observations and future plans

Eight stars from those two cross-match catalogues have been already observed by us spectroscopically. The spectrograms were acquired with the SARG instrument at the TNG telescope (La Palma, Spain) or at the Catania Observatory (Italy). The aim of those observations was to characterize the targets in terms of activity level, age, atmospheric parameters, and kinematic properties. Those of the spectra which we decided to make available publicly are stored in the same ftp directory as the cross-match catalogs. We plan to put in that directory more spectrograms of active stars observed by us within this project and also to provide a cross-match between the RASS-FSC (Voges *et al.* 2000) catalogue and the KIC.

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† ftp://ftp.ct.astro.it/pub/joanna/active/

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