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The Decay Law of Starspots (AIP – Klaus G. Strassmeier, with G. Rüdiger & M. Weber)

Starspots are local magnetic fields on the surfaces of stars, just as Sunspots. Their fields are strong enough to suppress the overturning convective motion and thus block or redirect the flow of energy from the stellar interior outwards to the surface and consequently appear as locally cool regions. As such, starspots are observable tracers of the internal dynamo activity and allow a glimpse into the complex internal magnetic field structure. Within this topic we plan to compare the global spot behaviour on the Sun with observations from stars. One particular goal would be to observe a decay law of an isolated starspot on stars with different rotational and various depth of the convective envelope. For this we must apply indirect image reconstruction techniques, a.k.a. Doppler tomography. Targets are active stars that are currently being monitored with the STELLA facility in Tenerife.

Measuring Stellar Magnetic Fields (AIP – Klaus G. Strassmeier, with T. Carroll & I. Ilyin)

Magnetic fields likely play an important role in almost any astrophysical target, from the early Universe to the Sun, Earth, and its environment. While numerical 3-D MHD simulations became more and more sophisticated in the previous years, magnetic-field observations are still extremely rare (except for the Sun). We propose to carry out such measurements with the high-resolution spectropolarimeter PEPSI of the 11.8m Large Binocular Telescope (LBT). A central scientific question in this thesis is to map the distribution of magnetic flux throughout the H-R diagram and qualify its impact on stellar evolution. Are there observable signs when the surface field transfers from dynamo-generated like in our Sun to fossil like in white dwarfs? Is the angular momentum loss from magnetized winds and its associated braking of stellar rotation just a brief epoch on or near the ZAMS?

A search for Maunder Minimum stars (AIP – Klaus G. Strassmeier, with C. Denker)

The solar Maunder minimum in 1650-1700 was a period in which the solar dynamo had operated at a much reduced efficiency. Despite that our numerical dynamo models have some difficulties to explain such nonlinearities it can be reproduced for the Sun. In the past decade a fair number of solar-type stars were found with chromospheric emission-line fluxes smaller than even the Sun's in its regular 11-year activity minimum. These stars were interpreted to be in a Maunder-minimum like state. Just recently though, it was shown that almost all of these stars were subgiants and their absolute chromospheric fluxes underestimated. In the proposed thesis, we suggest to search the AIP RAVE survey data for real Maunder-minimum stars and calibrate absolute CaII IRT emission-line fluxes for a total of 100,000 late-type stars, a factor of 1000 more than what is available from all previous surveys together. These calibrations would be very useful for the upcoming GAIA data. We hope to deduce statistically sound relations between magnetic flux and secondary stellar parameters, like metallicity, that play a major role during some parts of stellar evolution. The main goal shall be the development of a semi-empirical method to include magnetic flux into (low-mass) stellar evolutionary codes.

Molecular Doppler imaging: Probing the Dynamos of Fully-Convective Stars (AIP – Klaus G. Strassmeier, with M. Weber)

This thesis shall apply our new molecular Doppler-Imaging code to low-mass M stars and possibly to fully convective L dwarfs. The scientific goal is to detect surface inhomogeneities due to magnetic fields and to find evidence for differential rotation and interpret these with the predictions of concurrent turbulent dynamo models. Our new DI inversion code (A&A 444, 931) makes it possible to perform the reconstruction of surface temperature maps either solely from molecular features of, e.g., TiO, CO, OH, and CN bands, but also simultaneously with an unlimited number of atomic lines. Its kernel is based on the mathematical approach of quasi-optimal Kolmogorov-Wiener filtering of the eigenvalues of the Fisher information matrix. Our central scientific objective is to find out whether, and if yes, how different, the surface topology of fully-convective M and L dwarfs appears compared to solar-like interface-type dynamo stars. The long-term goal is to pave the way to quantify the structure and dynamics effects of stellar activity at the lower end of the main sequence, and its consequent implementation into stellar evolutionary models.

Photometric Spot Modelling with APT, CoRoT, Kepler and BRITE-Constellation (AIP – Klaus G. Strassmeier, with T. Granzer)

High-precision photometry can be used to time a spot's repeated appearance on the visible stellar hemisphere, and thereby obtain stellar rotation periods ten times more precise than from spectroscopic measurements. In principle it also allows to determine differential surface rotation in case the latitude of the spot can be determined, or at least constrained to a certain range. Combined with automatic telescopes, like our APTs and the upcoming STELLA-II & RoboTel facilities, photometry is unbeatable in obtaining long-term information on the growth and decay of spots and even on decades-long activity cycles. We have also access to some data from the space missions CoRoT and *Kepler* and possibly soon also from the Austrian-Canadian nano-satellite BRITE-constellation.

The PEPSI ``deep spectrum'' project (AIP – Klaus G. Strassmeier, with M. Steffen)

The idea of a PEPSI ``deep spectrum'' is to provide the highest quality optical spectra ever obtained for any star other than the Sun. A signal-to-noise ratio of 5000:1 at a spectral resolution of 1 km/s covering the entire optical spectrum from 390 to 1050nm is the goal. The thesis shall address the properties of stellar surface convection as a function of spectral type by measuring the asymmetry of selected spectral line profiles. This kind of information is essential for our understanding of the nature of `turbulence' in stellar atmospheres, and for the validation of current hydrodynamical models of stellar convection. The accurate determination of chemical abundances and isotope ratios is a fundamental building block of our knowledge about stellar nucleosynthesis and the chemical evolution of the Galaxy. The detection of ^{6}Li in solar metallicity stars might indicate the existence of an extrasolar planetary system, part of which has been accreted onto the star and thus contaminated its atmosphere with ^{6}Li-rich material. PEPSI is foreseen to see first light in 2011. Data would be taken in its commissioning phase.

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