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MUSICOS Observations of the Chromospherically Active Binary Star EI Eridani

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Abstract. We present first results on spectroscopic observations of the rapidly-rotating active binary star EI Eridani obtained during the MUSICOS multi-site campaign in 1998. Eight sites around the globe were involved in order to achieve surface images within a few rotations as EI Eridani's critical rotation period of 1.945 days makes it impossible to obtain time-resolved images from a single site. The data were split into groups in order to obtain consecutive, independent Doppler images. The preliminary results confirm the existence of a stable polar spot that changes in size and shape while low-latitute spots are found to be short lived. For the first time, it is possible to achieve consecutive, time-resolved Doppler images for EI Eridani. A preliminary investigation of differential rotation contradicts the results from Hatzes & Vogt (1992).

1. MUSICOS 98 and EI Eri

The rotation period of EI Eridani (HD 26337) of 1.945 days makes it impossible to achieve time-resolved Doppler images from a single observing site. At least two weeks of observations are necessary in order to avoid significant phase gaps that would reduce the quality of the Doppler images. However, the low-latitude spot distribution on EI Eri seems to change on timescales *shorter* than two weeks.

Consequently, EI Eridani was chosen as one of the main targets for the MUSICOS campaign in 1998. MUSICOS stands for MUlti-SIte COntinuous Spectroscopy and aims to achieve high-resolution, multi-wavelength spectroscopic observations from many sites around the globe, so that uninterrupted phase coverage of selected objects can be obtained. Major campaigns have taken place in 1989, 1992, 1994, 1996 and 1998. A review of the first three campaigns can be found in Catala (1998). On the World-Wide Web, information about the MUSICOS philosophy, instruments, and campaigns can be fount at http://www.ucm.es/info/Astrof/MUSICOS.html

The MUSICOS 1998 campaign involved eight northern and southern sites (see Fig. 1) and ten telescopes (mostly equipped with cross-dispersed echelle

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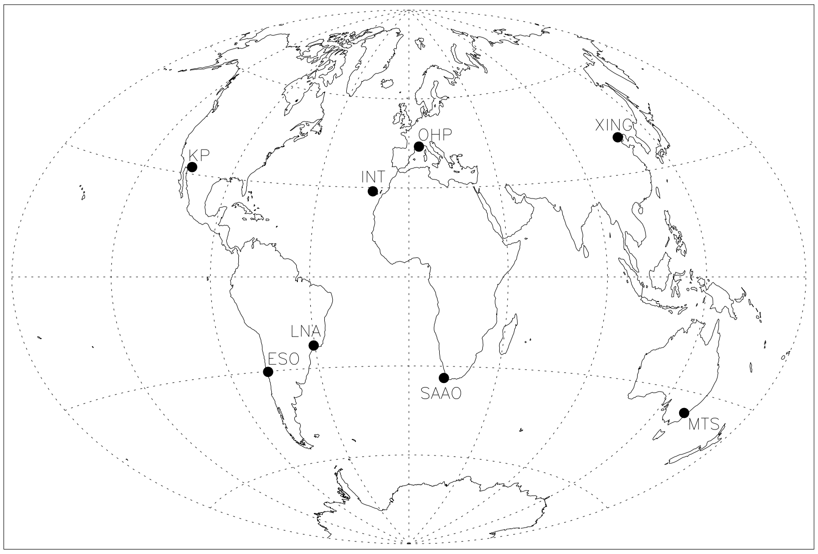

Figure 1. The (spectroscopic) sites involved in the MUSICOS 1998 campaign: INT, OHP, XING (BAO: Beijing Xinglong Observatory), KP (Kitt Peak), MTS/MSO (Mt. Stromlo), LNA, ESO and SAAO.

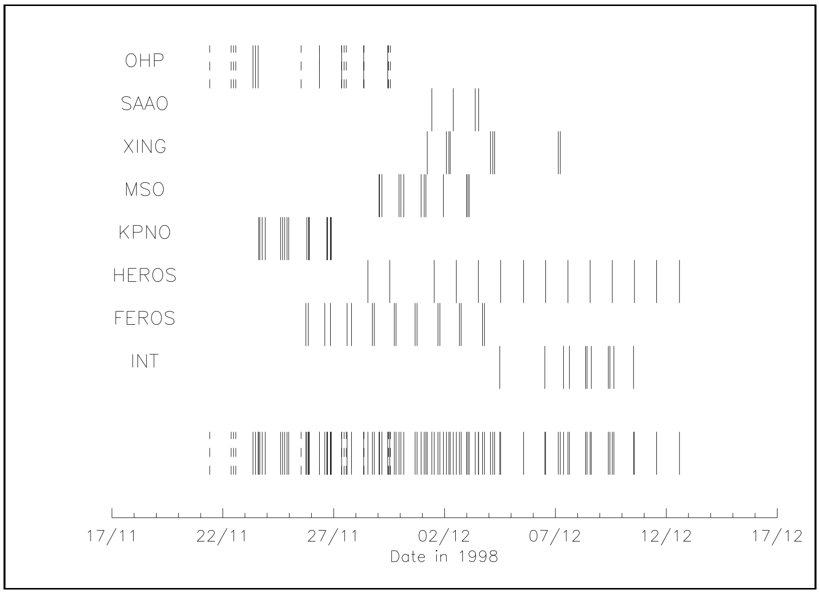

Figure 2. Time coverage of the EI Eri observations obtained during the MUSICOS 1998 campaign. The coverage of each site is shown, as well as the combined coverage of all sites (at the bottom of the figure). The dashed lines indicate spectra with wavelengths that could not be used for Doppler imaging.

site	telescope	spectrograph	number nights	resolving power	wavelength range [nm]	number spectra
OHP, France	1.5 m	Aurelie	6	22 000	652–672	13
	1.9 m	Elodie/Ha	7	43 000	390–690	7
SAAO, S. Africa	1.9 m	Giraffe	4	36 500	430–700	4
Xinglong, China	2.2 m	Echelle	7	43 000	397–700	0
				35 000	550–850	9
MSO, Austr.	1.9 m	Echelle	5	35 000	480–680	13
Kitt Peak, USA	0.9 m	Echelle	4	65 000	390–490	0
					530–700	19
ESO, Chile	0.9 m	HEROS	15	20 000	350–560	14
					580–865	14
	1.5 m	FEROS	9	48 000	368–855	18
LNA, Brazil	1.6 m	Coudé	0	60 000	663–672	0
INT, La Palma	2.5 m	ESA-MUSICOS	7	35 000	400–680	11

Table 1. Sites and instruments involved in the MUSICOS 1998 campaign and some of their most important characteristics: resolving power, wavelength range, the number of nights allocated at each site, the instrument, and the number of spectra obtained for EI Eri.

spectrographs) to fulfill the needs of six scientific programs and took place from November 20 to December 14, 1998. The involved sites were Haute Provence, Pic du Midi, La Palma, South Africa, ESO La Silla, Brazil, Kitt Peak, Xinglong, Mt Stromlo, Catania, and Caucasus SAO. The campaign was organized at ESTEC/ESA by Bernard Foing and Joana Oliveira. Table 1 lists the spectrographs used for this campaign.

Simultaneous photometric observations were carried out with the Wolfgang-Amadeus twin Automatic Photoelectric Telescope (APT), two robotic 75-cm telescopes for photoelectric photometry at Fairborn Observatory in the Sonoran desert near Tucson, Arizona (Strassmeier et al. 1997).

2. Doppler Imaging

A total of 95 of the spectra obtained with MUSICOS meet the classical wavelength region for Doppler imaging (Rice 1996; Rice & Strassmeier 2000) around 6420 (± 50) Å which provides up to four relatively unblended lines: Ca I 6439, Fe I 6430, Fe I 6411, and Fe I 6393. The 95 spectra cover 20 days and were split into several blocks covering 2 to 5 days each. Consecutive Doppler images can then be cross-correlated to reveal short-timescale drifts.

EI Eri has been observed and Doppler imaged since 1984 (see Vogt & Penrod 1983). The current results confirm the previous images (see Fig. 5) in that all surface maps of EI Eri show high-latitude spots surrounding or covering the rotational pole. This is in contradiction to what is seen on the Sun where spots occur only within ±35° of the equator. The high-latitude/polar spot seems to be long-lived (almost two decades now) but changes its size and shape on comparatively short timescales (of the order of one week). Spots along the

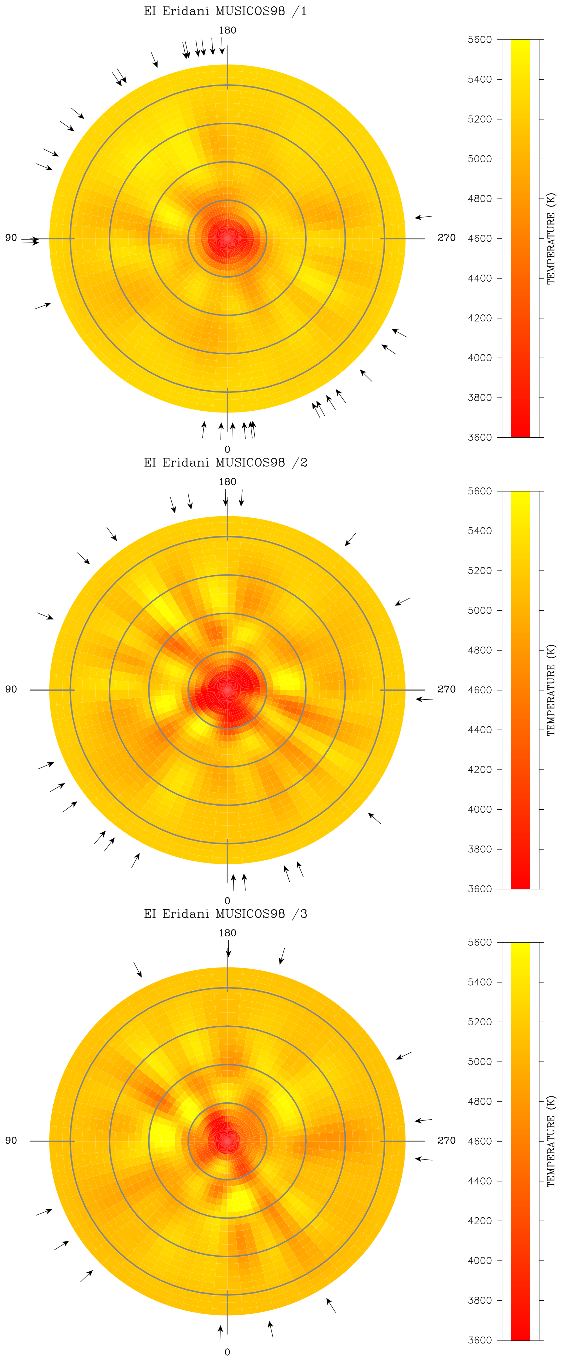

Figure 3. Preliminary Doppler images in pole-on view of the first three consecutive blocks of spectra (1: day 1-5; 2: day 6-9; 3: day 10-11). The circles indicate latitudes of -30, 0, 30, and 60°. The bright spots in /2 and /3 are believed to be artificial.

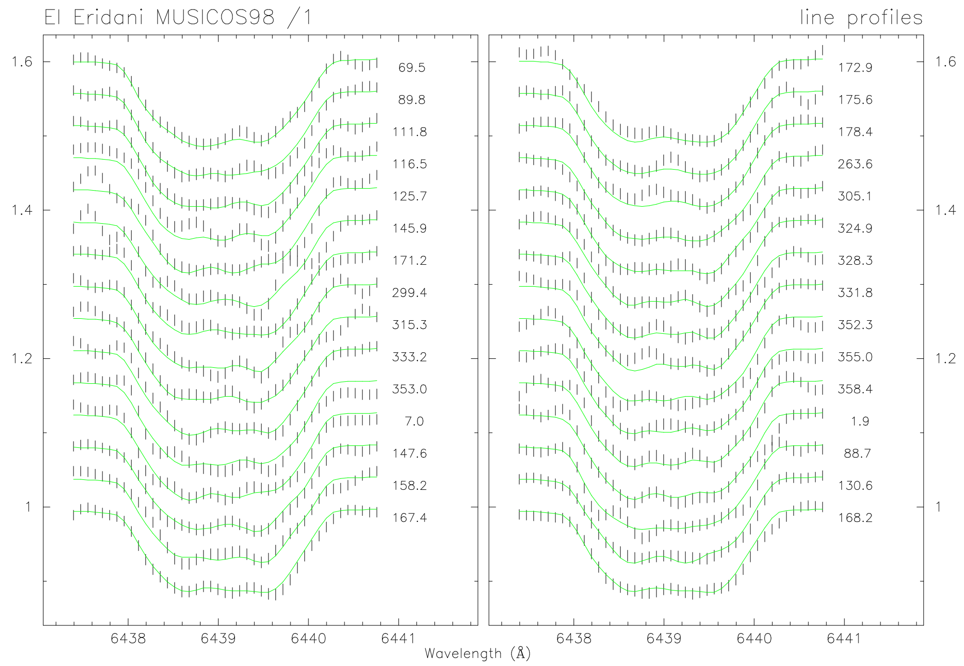

Figure 4. Observed (black vertical lines) and preliminary computed (solid green line) profiles of the Ca I 6439 line for MUSICOS98 /1.

stellar equator occur continuously; their lifetime tends to be very short and is not sufficiently well determined.

3. Discussion

All three MUSICOS images in Fig. 3 from Nov/Dec 98 show a very similar spot distribution. Some spots seem to decay, others emerge or drift. Also, the size and shape of the polar spot changes significantly.

We are currently in the status of cross-correlating the images in order to identify differential rotation. First results indicate a differential surface rotation that is opposite to the solar case, i.e. the pole rotates faster than the equator (in contradiction to Hatzes & Vogt 1992).

There are now theoretical models that explain the presence of high-latitude spots on rapid rotators (Granzer et. al 2000; Schüssler et al. 1996), but such huge polar caps are still not fully understood. To explain spot formation, we will have to find out whether the spots that we observe on active stars like EI Eridani are big "monoliths" or several smaller very dark spots, and on which time scales the spots form and decay.

Clearly, high spacial resolution interferometry with either ground-based telescopes (eg. LBT, VLTI) or space-based free-flying interferometers (e.g. SISP; see poster by Schrijver et. al) will solve this ambiguity.

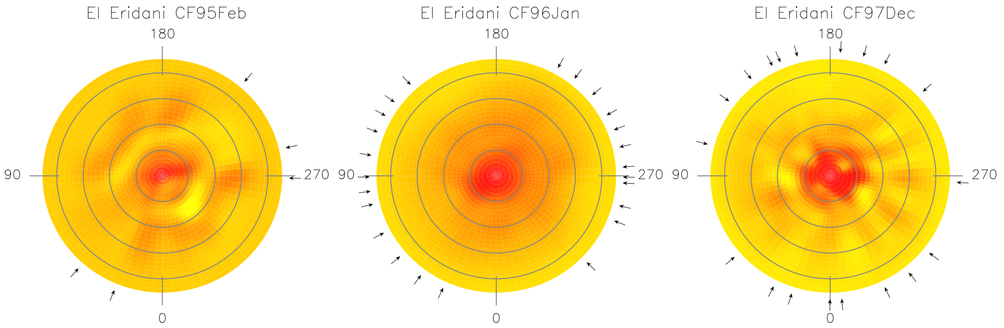

Figure 5. Doppler images of EI Eri in pole-on view from February 95, January 96, and December 97 (KPNO Coude feed).

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