CRIRES Science Verification Proposal

The capability of CRIRES for high precision radial velocity measurements of late-type objects

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Abstract:

Precise radial velocity measurements are important in many astrophysical astrophysical context. For example, very precise radial velocity measurements have lead to the indirect discovery of almost 200 extrasolar planets. Carrying out such measurements at infrared wavelength has several advantages: First of all late-type stars and brown dwarfs are much brighter at infrared wavelength, and secondly the RV-jitter caused by stellar activity is about one order of magnitude smaller in the infrared than in the optical regime. Infrared observations thus could open a new search window for companions of low-mass and active stars. Theoretically, it should be possible to detect even planets with CRIRES. However, the main disadvantage of the infrared regime is the large forest of telluric absorption lines. The aim of this project is to determine the accuracy that can be achieved with CRIRES by observing an old inactive M-star in two different nights, and one active star in order to demonstrate that RV-measurements are less affected by stellar activity.

Scientific Case:

The goal of this project is to test the RV-accuracy that can be achieved with CRIRES, in order to demonstrated that search programs for companions of low-mass stars, and brown dwarfs can successfully be carried out with this instrument. In the optical regime, typical errors of RV-measurements for spectrographs with a resolution of 60000 are about a few times 100 m/s, if a spectrum of an arc-lamp is is taken directly after the observations of the object. If such an accuracy is achieved, it would be possible to search for binary brown dwarfs and massive planets with orbital periods of a few days. Even if 100 m/s would be the limit, CRIRES would be much more efficient than UVES for searches of brown dwarf companions, because the V-K colours of L-types objects are between 9 and 17 mag! In the optical regime, an accuracy of about 20 m/s can be reached if the telluric lines are used as secondary reference, were the telluric spectrum is obtain by observing a B-star. The telluric spectrum thus is not divide out but used as a reference. The radial velocity of a late-type star is then derived by fitting the an FTS sunspot spectrum, or in the case of L-type dwarfs, models published by Peter Hauschildt as a second component to the data. The method thus is similar to the Iodine-cell-method in the optical regime but limited by shifts of the telluric lines due to pressure variations in the atmosphere of the earth, and by the wind. We ask for one setting in the J-band, one in the H-band and one in the K-band. Which of the three regions is best can not easily be judged beforehand. Although the S/N will be better at longer wavelength, the number of telluric lines are also larger. In the H-band we choose the 1571.283-1610.740 nm (setting 33/-1/i) region, because M-stars have many spectral lines in this region, and in the J-band the 1237.153-1266.675 nm (setting 45/0/n), because the number of telluric lines is not too high but still sufficient for the secondayry wavelenthin calibration these regions. If possible, we would also like to test the N_2O absorption cell of CRIRES. N_2O has 25 strong absorption-lines in the region from 4418.2 to 4434.3 cm-1 (2255 - 2263 nm), which would be covered by the 2253.963 to 2304.582 nm (setting 25/1/n). Since this setting also covers a large number of CO-lines of the M-star we choose this region as a second setting. In this case the algorithm to reduce the data similar to data taken with the iodine cell in the optical. However, because of the forest of telluric absorption lines, the classical iodine+star model has to be extended to a iodine+star+atmosphere model. The cell has the advantage of controlled environment, e.g. avoiding pressure changes. In the optical regime 3 m/s are routinely achieved with an I_2-cell. Deming et al. (1987, ApJ 316, 771) achieved an accruray better than 5 $m\,s^{-1}$ with an N_2O-cell, and the FTS on the McMath-Pierce solar telescope.

The accuracy can be achieved with the N_2O-cell and CRIRES is what we would like to find out. Additionally, to the inactive M-star GJ 9847, we would also like to observe the active star AU Mic, in order to demonstrate that RV-measurements are less effected by stellar noise at IR wavelength, the in the optical regime. All these test together will allow to find out what accuracy can be achieved, and which is the best strategy for high precision radial velocity measurements. Something that can not be done in the framework of a normal proposal.

Required observing time

Target	**RA**	**DEC**	**Wavelength Band**	**Magnitude**	**DIT**	**NDIT**
AU Mic	20 45 09.5	-31 20 27	1237.153-1266.675 nm	J=5.4	15s	20
SpT=M1			1571.283-1610.740 nm	H=4.8	15s	20
			2253.963-2304.582 nm	K=4.5	15s	20
teluric:	20 46 20.1	-39 11 57	1237.153-1266.675 nm	H=5.7	20s	15
HD 197630			1571.283-1610.740 nm	H=5.7	20s	15
SpT=B8V			2253.963-2304.582 nm	K=5.6	20s	15
GJ 9847	00 01 25.8	-16 56 54	1237.153-1266.675 nm	H=8.0	60s	5
SpT=M0			1571.283-1610.740 nm	H=7.4	60s	5
			2253.963-2304.582 nm	K=7.2	60s	5
teluric	23 42 43.3	-14 32 42	1237.153-1266.675 nm	H=4.3	20s	15
105 Aqr			1571.283-1610.740 nm	H=4.6	20s	15
SpT=B9V			2253.963-2304.582 nm	K=4.6	20s	15

Layout of the observations, and observing time requested: The idea of the project is to determine the RV-accuracy that can be achieved with CRIRES. For this reason the two targets should be observed in at least in two different nights. Since we would like to try out the accuracy that can be achieved with and without the N_2O-absorption cell in the K-band, the following observing cycle is requested: One spectrum of the object with the cell, one without the cell, then a wavelength calibration frame, and then the B-star. The same cycle should then be repeated in the J, and H-band but with the cell. Ideally, both stars would be observed in both nights in this way. Since the overheads per target are are 5.0 minutes for the acquisition, 0.2 minutes for changing the wavelength, and 5 minutes for an attached wavelength calibration observation. 65 minutes are required for per object per night (K-band: AU 5 minutes for the acquisition object, 5 minutes exposure with cell, 5 minutes exposure without the cell, 5 minutes for the acquisition telluric standard, 5 minutes observation of the standard star.). Thus in total 2.2 hours per night, or **4.4 hours** for both targets, for both nights, and both wavelength regions.