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Infrared Spectroscopy Data Reduction with ORAC-DR

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Abstract. ORAC-DR is a flexible and extensible data reduction pipeline suitable for both on-line and off-line use. Since its development it has been in use on-line at UKIRT for data from the infrared cameras UFTI and IRCAM and at JCMT for data from the sub-millimetre bolometer array SCUBA.

We have now added a suite of on-line reduction recipes that produces publication quality (or nearly so) data from the CGS4 near-infrared spectrometer and the MICHELLE mid-infrared Echelle spectrometer. As an example, this paper briefly describes some pipeline features for one of the more commonly used observing modes.

1. Background on ORAC-DR

As part of the Observatory Reduction and Acquisition Control project (ORAC[2], Wright et al. 2001) for the United Kingdom Infrared Telescope (UKIRT), a flexible and extensible data reduction (DR) pipeline has been developed. The ORAC-DR pipeline design was presented previously by Economou et al (1998) and Jenness & Economou (1999) and makes extensive reuse of existing data reduction packages (Economou et al. 1999). ORAC-DR is a data-driven pipeline with simple ASCII files called recipes that contain data reduction instructions. ORAC-DR has been in use at UKIRT for on-line reduction of data from the UFTI and IRCAM/TUFTI infrared cameras, as well as at the James Clerk Maxwell Telescope for the on-line reduction of data from the Submillimeter Common-User Bolometer Array (SCUBA, Holland et al. 1999).

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[2]ORAC is a joint project of the Astronomy Technology Centre, Edinburgh and the Joint Astronomy Centre, Hawaii.

This paper describes the recent addition to the pipeline of recipes and primitives for the reduction of data from the UKIRT infrared spectrometer CGS4. The support for infrared spectroscopy added for the CGS4 instrument will also form the basis for the support of the Mid Infra-Red Echelle Spectrometer (MICHELLE) when it is in use at UKIRT[3].

2. Requirements for IR Data Reduction at UKIRT

Since the primary purpose of on-line data reduction is to give observers the ability to assess the quality of their data in near real-time and modify their observing strategy as necessary, this is a primary requirement for the IR spectroscopy component of ORAC-DR. However, since experience with other supported instruments has shown it is often possible to obtain publication quality results in the on-line data reduction process, this too is a goal whenever practical.

Online data reduction becomes even more important with the advent of multi-wavelength observers (who may not be experienced infrared observers) and flexible scheduling (where the observer is not necessarily acquainted with the scientific aims of the observations that he or she may be carrying out). There is an additional concern for the potential future user who may be accessing the data through a public archive. Online reduction at the telescope to produce near-publication quality data ensures that all suitable calibration frames are taken and that the data can even be automatically reducible at retrieval from the archive (see e.g., Jenness et al. 2001).

3. Feature Highlights

The UKIRT 1–5 micron spectrometer CGS4 is typically used in the following observing mode: the usual array calibration frames (for example bias, flat, dark and arc) are taken, then a star of known magnitude and spectral type at an airmass near that of the astronomical target is observed. This is used later for removal of the atmospheric response from the data. Both standard stars and astronomical targets are usually observed with a nodding technique to enable accurate sky removal. The calibration frames, standard star frames, and target frames all have to be processed and retrieved at appropriate points during the reduction in order to produce meaningful scientific output for observers.

The flexible architecture of ORAC-DR has allowed us to provide "added-quality" features with very little programming effort. For example, a data reduction step requiring user intervention is processing the spectrum of a standard star into a normalised calibration frame subsequently used to remove atmospheric features from the astronomical target. Prior to the advent of ORAC-DR, this process requiring knowledge of the standard star's temperature and infrared magnitude was not performed automatically in real time. The ORAC-DR pipeline can now use either a local catalogue or an http connection to an astronomical database, together with the standard star name or the RA and Declination coordinates from the FITS header, to determine the spectral type

[3]The MICHELLE instrument is a shared between the UKIRT and Gemini projects

and magnitude. From these the stellar temperature and color and hence the appropriate infrared magnitudes are derived. All this takes place in the time it takes to acquire the next frame.

Future plans call for the addition of such features as automatic wavelength calibration from observation of an arc lamp.

4. Implementation Details

For spectroscopy ORAC-DR currently makes use of the following external applications: Figaro (Shortridge et al 1999; Shortridge 1993), Kappa (Currie & Berry 2000) and CCDPACK (Draper, Taylor & Allan 2000), all supported by Starlink and driven by the ADAM messaging system (Allan 1992). ORAC-DR itself is written in Perl and is described by Economou et al. (2000).

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