Description of the procedure for combining individual orders of Echelle spectra into normalized 1D spectra

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Basic scheme

1. Fit continuum to each of the individual orders of the spectrum.
   noao.imred.echelle.continuum [name]`.ec` [name]`.cont`
2. Use the program `contlim` to create an ASCII file with the information on the useful wavelength range for the orders.
   `contlim` [name]`.cont.`[fits_extension] > `wtab`[name]`.txt`
3. Create a list of spectra to be processed. The names without extension, one per line.
4. Use the IRAF script `es1.cl` to proceed with the combining itself.
   task es1=es1.cl
   es1 list.txt

Notes on the name conventions

There are several strict conventions which are used in the procedure described here.

- The filenames for input Echelle spectra must have the following format: [name]`.ec.[`fits_extension]
- The filenames for the continua created in step 1. must have the following format: [name]`.cont.[`fits_extension]
- The text files with the information on the wavelength range must have the following format: `wtab`[name]`.txt`
- The output normalized spectra are written into files with the following filenames: `s`[name].[fits_extension]

Description of `contlim`

Program `contlim` helps in fast and easy determination of useful wavelength range for the individual Echelle orders. For the analysis it uses a continuum fit to each of the orders.
First the peak count and the extrema of the slopes on both sides of the peak are found. Then the useful range is determined by taking into account the following criteria:

- counts must be higher than the user defined level
- counts must be higher than the threshold defined as a fraction of the peak
- slopes on both sides of the peak must be higher than a user defined fraction of extremal slope

The slopes are calculated locally as a difference between the subsequent pixels in the continuum.

Usage: `contlim` [name]`.cont.`[fits_extension]

Input file with the continua of the spectrum orders must be in the FITS format.
User defined parameters are read from the file `contlim.par`. This file must be located in the working directory.
Each of the parameters should be written in the beginning of the subsequent lines and the rest of the line is ignored. The parameters should have the following order:

1. number of the first aperture

   Integer number.

   This parameter is obsolete. It is ignored if the ECORD# cards are found in the FITS header.
2. ratio between the maximum and the minimum accepted levels in the continuum

   Floating point number.

   We suggest to use 10.0 In the case of low signal spectra it may be set to some smaller number.
3. lower threshold of the accepted continuum levels

   Floating point number.

   This number may be set after visual inspection of the continuum level in the spectrum orders.
4. ratio between the minimum slope of the falling side of the continuum and the flattest acceptable part of the falling continuum

   Floating point number.

   We suggest to use 2.0
5. ratio between the maximum slope of the rising side of the continuum and the flattest acceptable part of the rising continuum

   Floating point number.

   We suggest to use 2.0
6. verbose level

   Integer number.

   0 (zero) must be used for the purpose of a real work and higher numbers may be used for debugging.

Output is written to the terminal and it may be redirected to a file.

Example content of a `contlim.par` file:

```
76        // number of the first aperture
10.0      // maximum/minimum accepted counts ratio
50.0      // minimum accepted counts
2.0       // minimum differential ratio
2.0       // maximum differential ratio
0         // verbose level [0-2]
end
```

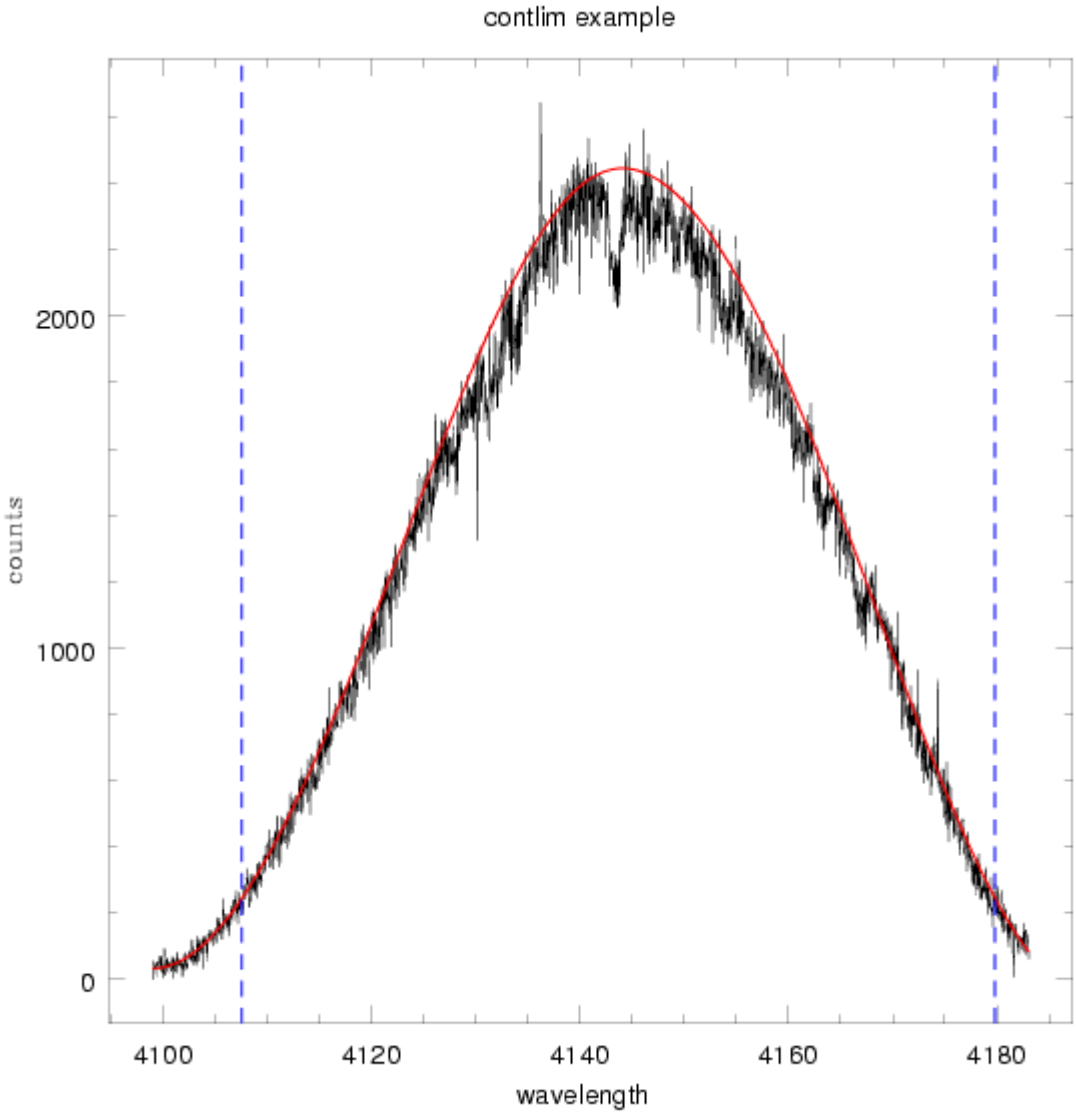

Illustration 1: Example plot of a single order from Echelle spectrum with the continuum fit overplotted. Vertical dashed lines mark the boundaries of the wavelength range selected by program contlim with the parameters given in the example of the content of contlim.par file.

Notes to es1.cl

It is left to the user to load the *noao.imred.echelle* package within the IRAF before running this script. In some versions of IRAF it is also important to load *noao.imred.onedspec* to have the *scombine* procedure running properly.

Since there is a little bug in the IRAF scripts the user has to take care for the *log* parameter in the *dispcor* and *scombine* procedures. This parameter controls if the wavelength is written in the linear or in the logarithmic scale and it cannot be set in a script.

A script `es2.cl` prepared for simultaneous combining of two channels of the MIKE spectra into a single 1D spectrum is available from the author.