ONEDSPEC Package Revisions Summary: IRAF Version 2.10

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ABSTRACT

This paper summarizes the changes in Version 3 of the IRAF **onedspec** package which is part of IRAF Version 2.10. The major new features and changes are:

- **Identify** and **reidentify** now treat multispec format spectra and two dimensional images as a unit.
- **Reidentify** supports both tracing (the old method) and always starting with the primary reference vector when reidentifying other vectors in a two dimensional reference image.
- **Reidentify** matches reference lines or apertures when reidentifying those vectors in different images rather than tracing.
- **Reidentify** has an interactive capability to review suspect reidentifications.
- **Reidentify** provides the capability to add new features.
- The task **msdispcor** provides for spatial interpolation of wavelength zero point shifts from simultaneous arc spectra.
- The new task **scopy** copies subsets of apertures and does format conversions between the different spectrum formats.
- The new task **sapertures** adds or modifies beam numbers and aperture titles for selected apertures based on an aperture identification file.
- The new task **sfit** fits spectra and outputs the fits in various ways. Apertures in multispec and echelle format are fit independently.
- The task **continuum** now does independent fits for multispec and echelle format spectra.
- **Splot** now allows deblending of any number of components and allows simultaneous fitting of a linear background.
- The new task **fitprofs** fits 1D gaussian profiles in images.

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1. Introduction

Though most of the ONEDSPEC package is unchanged there have been significant changes to a number of the commonly used tasks in IRAF Version 2.10. The changes will be made available as part of an external package prior to the release of V2.10. This paper summarizes the changes and new features. The changes primarily apply to multispec or echelle format spectra.

Tables 1 and 2 summarize most of the major and minor changes in the package.

TABLE 1: Summary of Major New Features and Changes

- **Identify** and **reidentify** now treat multispec format spectra and two dimensional images as a unit allowing easy movement between different image lines or columns. The database is only updated upon exiting the image.
- **Reidentify** supports both tracing (the old method) and always starting with the primary reference vector when reidentifying other vectors in a two dimensional reference image.
- **Reidentify** matches reference lines or apertures when reidentifying those vectors in different images rather than tracing.
- **Reidentify** has an interactive capability to review suspect reidentifications.
- **Reidentify** provides the capability to add new features.
- The task **msdispcor** allows using auxilary reference spectra to provide a shift in the wavelength zero point to the primary dispersion functions. This includes spatial interpolation of simultaneous arc spectra in multifiber spectrographs.
- The new task **scopy** copies subsets of apertures and does format conversions between the different spectrum formats.
- The new task **sapertures** adds or modifies beam numbers and aperture titles for selected apertures based on an aperture identification file.
- The new task **sfit** fits spectra and outputs the fits in various ways. This includes a new feature to replace deviant points by the fit. Apertures in multispec and echelle format are fit independently.
- The task **continuum** now does independent fits for multispec and echelle format spectra.
- **Splot** now allows deblending of any number of components and allows simultaneous fitting of a linear background.
- The new task **fitprofs** fits 1D gaussian profiles to spectral lines or features in an image line or column. This is done noniteractively and driven by an input list of feature positions.

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TABLE 2: Summary of Other New Features and Changes

- The **identify** database format uses aperture numbers rather than image sections for multispec format spectra.
- The apertures in multispec format images need not be in the same order or even the same number of apertures as the reference image in **reidentify** or **msdispcor**.
- An automatic write parameter has been added to **identify**.
- The tasks **msdispcor** and **specplot** support the extra information in the third dimension of multispec format spectra which is optionally output by the **apextract** package.
- **Msdispcor** and **specplot** now include a logfile.
- **Splot** selects spectra from multispec or echelle format by their aperture number. Also a new keystroke was added to select a new line/aperture without having to enter the image name again.
- The task **specplot** may select apertures from a multispec or echelle format spectrum.
- The aperture identification in multispec format is used, if present, for labeling in **splot**, **specplot**, and **standard**.

2. IDENTIFY and REIDENTIFY

These tasks have been modified for greater flexibility when dealing with two dimensional images and multispec format spectra in particular. These tasks were initially designed primarily to work on one dimensional images with provisions for two dimensional images through image sections and tracing to other parts of the image. Now these tasks treat such images as a unit.

The task **identify** has three added keystrokes, 'j', 'k', and 'o'. These provide for moving between lines and columns of a two dimensional image and different apertures in a multispec format spectrum. When changing vectors the last set of features and fit are recalled, if they have been previously defined, or the last set of features and fit are inherited. For efficiency and to minimize queries, the feature information from all the lines or apertures is not written to the database until you quit the image (or explicitly write it) rather than one at a time. A new parameter was also added, *autowrite*, which may be set to automatically write the results to the database rather than querying as is currently done.

The format of the database entries have also been slightly modified in the case of multispec format images. Instead of using image sections as part of the image name to define different vectors in the image (this is still the case for regular two dimensional images) the aperture number is recorded. This decouples the solutions for an aperture from the specific image line allowing reference images to have a different aperture order and additional or missing apertures.

While the changes to **identify** are minor as far as usage, the task **reidentify** is quite different and is essentially a new program. Much of the complexity in this task relates to two dimensional images. Two additions that apply to both one and two dimensional images is the capability to add features from a coordinate list and to interactively review the reidentifications using **identify**. The addition of new features may be useful in cases where the signal-to-noise varies or to compensate for lost features when tracing across an image. The review capability first prints the statistical results and then ask the user if they want to examine the results interactively . This allows basing the decision to interactively examine the features and fit based on this information. Ideally, only a few of the worst cases need be examined interactively.

There are two phases of reidentifications which apply to two dimensional and multispec format images. In the first phase, one needs to expand the identifications in the reference image from an initial, interactively defined line, column, or aperture to other parts of the reference image. A very important change is that there are now two ways to transfer the features list; by successive steps (tracing) using the previous results as a starting point (the only method provided in the previous version) or always starting from the original reference list. The first method is suitable for long slit spectra which have significant positional trends across the image. If a feature is lost, however, the feature remains missing (barring automatic addition as mentioned above) for all following lines or columns. The latter method is best if there are only small variations relative to the initial reference or in multispec format spectra where there is no inherent relation between apertures.

The second phase of reidentifications is between the reference image and other images. In the previous version the primary reference vector was transferred to the new image and then tracing would be applied again. This compounds the problem with losing features during tracing and prevents any possible reidentifications from multispec images in which the wavelength range may vary greatly. In the new version there is a direct reidentification from the same line, column, or aperture in the reference to that of the next image. In the case where different apertures may have significantly different wavelength coverage, as occurs with aperture masks, it will at least be possible to

interactively identify features and coordinate functions for each aperture, using the scrolling capability in the new **identify**, in just a single image and then correctly transfer the features to additional images.

For multispec format spectra the database information is organized by aperture number independent of image line number. Thus, it is possible to reidentify features in multispec format spectra even if the aperture order is different. If there is only a partial overlap in the aperture set only those apertures having an entry in the reference image will be done.

3. MSDISPCOR

The task **msdispcor** dispersion corrects (rebins to a linear dispersion function) multispec format spectra. It was introduced in V2.8 of IRAF in the prototype **imred.msred** package. A number of changes have been made in this task as summarized here.

The most fundamental change is support for spatial interpolation of reference dispersion functions from a subset of apertures to other apertures originating at different positions in a two dimensional image. This is primarily intended for the case of comparison arc spectra which are interspersed with object spectra in multifiber spectrographs. It would also be useful in digitized photographic spectra having calibration spectra exposed next to the object spectrum. While usable directly, this feature is intended for the processing scripts in the new **imred** fiber instrument packages.

The interpolation is only for a wavelength zero point shift, as determined by **reidentify** with *refit*=no. The full dispersion function is still provided by a calibration image covering all apertures. Thus, the simultaneous arc apertures are used to monitor shifts in the detector relative to the full calibration which includes the relative differences between each aperture and the arc monitoring apertures.

The multispec spectra containing the apertures used for the spatial wavelength zero point corrections are specified in the image header using the keywords REFSHFT1 and REFSHFT2. These are analogous to the REFSPEC keywords used to define the reference dispersion functions for the apertures.

As part of the general theme of multispec format support the multispec dispersion reference spectra may have additional spectra and need not be in the same order. However, all aperture in the images being dispersion corrected must have dispersion relations in the database. Multispec format spectra may include additional data in the 3rd image dimension produced by the new **apextract** package. **Msdispcor** rebins this information in the same way as the spectra, thus, preserving the information but now in linear wavelength sampling.

A new parameter, *logfile*, has been added to capture information about the dispersion correction process.

4. SCOPY and SAPERTURES

The task **scopy** is intended to bridge the gap between the various spectrum formats and provide a tool to flexibly manipulate multispec format spectra. It replaces the more primitve tasks **msred.msselect** and **echelle.ecselect**. Basically, this task copies all or selected spectra from one format to a new image or images of the same or different format. The typical uses are:

- Extract selected spectra from a multispec format image.
- Allow converting the voluminous onedspec format from previous reductions done before the multispec format was introduced into the more compact multispec format.
- Splice selected apertures from different multispec images into a new multispec image.
- Provide a quick way to convert lines or columns from two dimensional long slit images into one dimensional spectra. This replaces the task **proto.toonedspec**.

Because **scopy** can easily change the number and order of apertures in the multispec image format it is important that the other tasks which use the multispec format have been modified to be insensitive to which line a spectrum is in and generally key off the aperture number.

The task **sapertures** is a simple way to set the aperture identifications, APID keyword, and beam number, second field of APNUM keyword, based on the aperture number and a simple text file. The text file contains lines with aperture number, beam number, and (optional) title. This file is used by the **apextract** package as well. Its likely usage is to change image titles which might be wrong because of being inherited from an aperture reference image during extraction.

5. SFIT, CONTINUUM, and ECCONTINUUM

The original version of **continuum** was a simple script based on the task **fit1d**. The problem is that **fit1d** is intended to process all the lines or columns in a two dimensional image noninteractively. To do this it applies the same fitting parameters to every line or column. The interactive step in this task is simply to adjust fitting parameters. For spectra, particularly multispec and echelle format spectra, one often needs to fit each spectrum interactively and independently. When this problem was encountered for the **echelle** package Rob Seaman wrote a nice program, **eccontinuum**, which allows fitting a set of orders and keeps track of which orders have been fit.

The general feature of the continuum fitting tasks is that they fit spectra using the **icfit** interactive function fitting interface. The results of the fit may be output as the fit itself, the difference or residuals, the ratio, or the input data with rejected points replaced by the fitted values. The last feature is new an provides a useful spectrum cleaning option. The general equivalent to **fit1d** is the new task **sfit** which provides the same independent fitting and image line selection capabilites as **eccontinuum**. Note this task is line oriented and does not select by aperture or order number. The revised version of **continuum** is now based on **sfit** and provides the independent continuum fitting capability for onedspec and multispec format spectra that **eccontinuum** provides for echelle format spectra. Technically what has been done is that **sfit**, **continuum**, and **eccontinuum** are the same task; essentially the task written by Seaman for echelle data. They differ in the default parameters with the continuum fitting task having default parameters providing continuum normalization (ratio) output and iterative rejection values for excluding lines.

6. SPLOT, FITPROFS, and SPECPLOT

Splot has been modified to better support multispec and echelle format images. The line selection for multispec and echelle format spectra is now in terms of the aperture number rather than the image line. The aperture title is used in place of the image title if present.

The restriction to a maximum of four lines in the gaussian fitting and deblending option of **splot** has been lifted. Any number of lines may be fit simultaneously, though execution time will become long for a large number. In addition the fitting allows determining a simultaneous linear background as well as using the cursor defined points. The positions of the lines to be fit may be marked with the cursor, typed in, or read from a file. The last choice is a new feature.

In the past many people have used **splot** for bulk, noninteractive gaussian fitting by going through the trouble of redirecting the cursor input, ukey input, text output, and graphics output. The main reason this has been done is the lack of a one dimensional gaussian fitting task. The task **fitprofs** has been added to provide simultaneous gaussian fitting. This task takes a list of positions and optional sigmas and fits gaussians to a list of images or spectra. The lines, columns, or apertures may be selected. In addition a linear background may be specified or included in the fitting. The output consists of any combination of text similiar to the **splot** logfile, plots showing the data and fit, and image output of the fit or the difference. This task is noninteractive; the interactive version is the deblend command of **splot**. The multiparameter, nonlinear fitting software is the same as used in **splot**.

Fitprofs complements the task **stsdas.fitting.ngaussfit** from the **stsdas** package (available from the Space Telescope Science Institute). This task is similar in character to **fit1d** and has an interactive one dimensional nonlinear function fitting interface similar to **icfit**.

The task **specplot** has a new parameter to select apertures to plot. Previously there was no way to limit the apertures plotted other than with image sections. All associated lines of a multispec spectrum (those in the third dimension) are also plotted for the selected apertures. This extra information is a new option of the **apextract** package.