CORONAL DIAGNOSTIC SPECTROMETER

SOHO

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Post-recovery broadened line profiles

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1 The post-recovery line profiles

The SOHO satellite lost power on 25 June 1998. Contact was re-established on 3 August 1998, and full power was restored on 16 September 1998. When CDS was recovered in October 1998, it was discovered that the line profiles in both NIS-1 and NIS-2 had changed. This can be seen in Figure 1.

The largest change is in the NIS-1 spectrum, which has acquired substantial wings on both the red and blue sides of each line profile. However, lines can still be differentiated from each other. For example, notice that the Mg VII line at 367.7 Å is still visible as a bump on the Mg IX 368.1 Å line profile, though not perhaps as well as before. On the other hand, the Fe XI line at 369.2 Å used to be well separated from the Mg IX line, but is now within the wings of that stronger line.

The wings in the NIS-2 spectrum are not as bad as in NIS-1, and mostly affect the red sides of the lines. Here too, note that the Ar VII line at 585.8 Å is now well within the wing of the much stronger He I 584.3 Å line.

The challenge for the analysis of post-recovery NIS data is to model these broadened line profiles, and to recover the ability to separate out the individual lines. This report describes one function which appears to well match the new line profiles.

2 The broadened Gaussian line profile function

We model the line profiles as a combination of a Gaussian term plus a term describing the wings. The Gaussian term is defined in the normal way as

$$G(\lambda) = \exp\left[-\frac{1}{2}\left(\frac{\lambda-\lambda_0}{\sigma}\right)^2\right] \tag{1}$$

The wings are defined by the function

$$W(\lambda) = \frac{1}{\left(\frac{\lambda-\lambda_0}{\sigma'}\right)^2 + 1} \tag{2}$$

The combined function describing the line profile is then

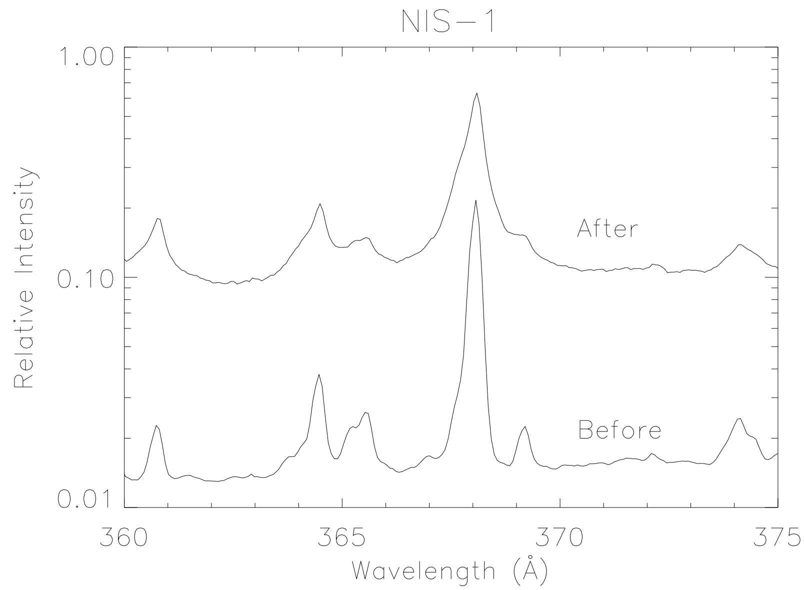
$$B(\lambda) = A_0[(1-\alpha)G(\lambda) + \alpha W(\lambda)] \tag{3}$$

where α can have different values for the left and right wings. Initial tests of this function allowed the parameter σ' to vary along with the rest of the parameters. However, it was found that the resulting function was not very sensitive to the exact value of σ', and it was decided to define this as

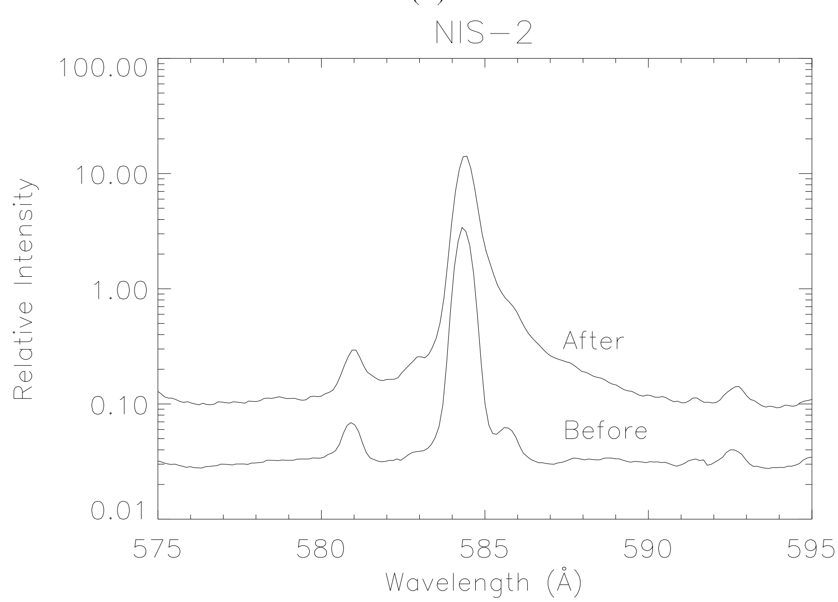
$$\sigma' = 2\sigma\sqrt{2\ln(2)} \tag{4}$$

which appeared to match the values of σ' found through fitting. This definition of σ' has the property that the full-width-half-maximum of the function $W(\lambda)$ has exactly twice the full-width-half-maximum of $G(\lambda)$.

This function is implemented through the IDL routine COMP_BGAUSS, with the calling sequence:



(a)



(b)

Figure 1: Comparison of the line profiles from before loss-of-contact and after recovery for (a) NIS-1, and (b) NIS-2. The lower line in each plot demonstrates what the spectrum looked like before loss-of-contact on 25 June 1998. The upper line demonstrates the broadening of the spectral line profiles after recovery in October 1998. The before and after spectra have been displaced vertically from each other in each plot for easier viewing.

COMP_BGAUSS, X, A, FIT [, PDER]

The parameters A of the function are:

A_0	The amplitude of the line profile.
$A_1 = \lambda_0$	The line center position.
$A_2 = \sigma$	The Gaussian width.
$A_3 = \alpha_{\rm right}$	The relative amplitude of the right wing.
$A_4 = \alpha_{\rm left}/\alpha_{\rm right}$	The ratio of the amplitude of the left wing to the right wing.

For NIS-2, the best results appear to be achieved with $A_3 = 0.317$, and $A_4 = 0.279$. It's a little more difficult to be precise with NIS-1, but good results can be obtained with $A_3 = 0.8$, and $A_4 = 1.0$.

3 Implementation within CFIT

The routine MK_COMP_GAUSS can be used to create CFIT-compatible broadened Gaussian components, in exactly the same way that MK_COMP_GAUSS creates normal Gaussian components. Unless the CONST keyword is passed to MK_COMP_GAUSS, the parameters A_3 and A_4 will be defined as constants rather than as parameters to be fitted. This simplifies the fitting process.

XCFIT has been modified to add another pull-down menu, just to the left of the "Add component..." pull-down menu. Initally, this button will have the value "Gauss". However, one can switch between normal Gaussian profiles and broadened Gaussian profiles ("BGauss"). This will determine the type of the next component to be added to the fit. XCFIT will automatically set the initial values of the parameters A_3 and A_4, depending on the initial line position. If the position is less than 400, then NIS-1 will be assumed. Otherwise, values compatible with NIS-2 will be set.

Figure 2 demonstrates the fitting of NIS-1 and NIS-2 line profiles with broadened Gaussians, using XCFIT. Lines were found at positions close to those found in spectra from before loss-of-contact, although in a couple of cases in NIS-1 one line was fitted where two closely blended lines were found before. The Mg VII and Mg IX lines at 367.7 Å and 368.1 Å respectively were separated, although it's unclear how well this was done.

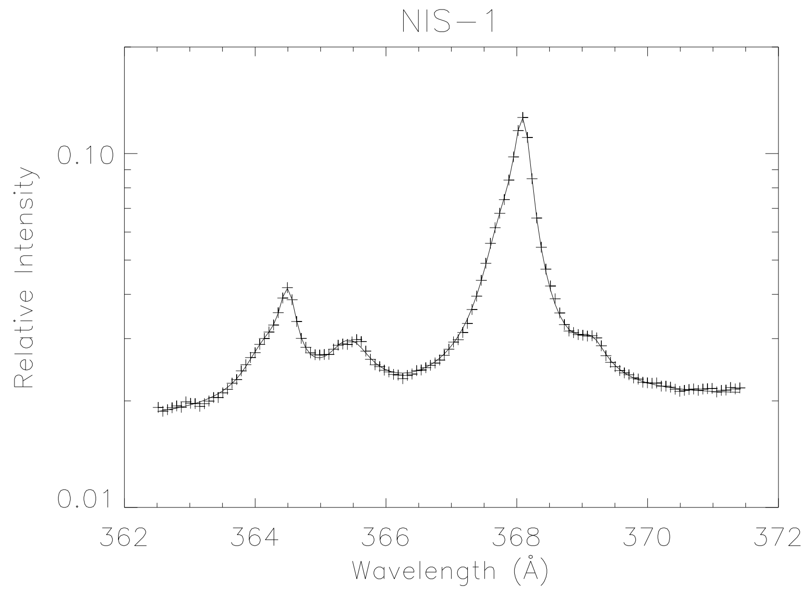
4 Line intensities

Once the line profiles have been fitted, the parameters A needed to be interpreted in terms of physical quantities. The line position is given by A_1 as before. Integrating equation 3 from $-\infty$ to $+\infty$ gives the total line intensity I as

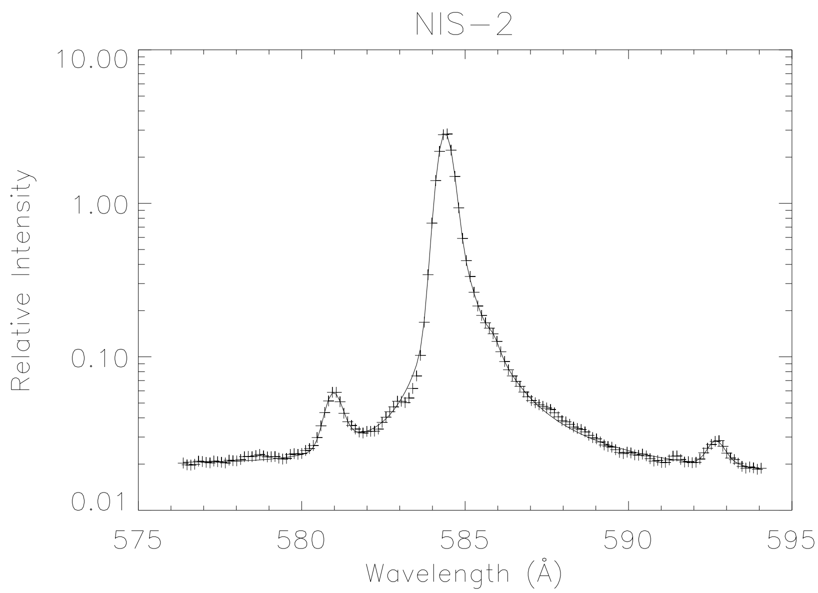
$$I = A_0 A_2 \left[\left(1 - \frac{A_3}{2}(1 + A_4) \right) \sqrt{2\pi} + A_3(1 + A_4)\pi\sqrt{2\ln(2)} \right] \tag{5}$$

If we plug in the default values for NIS-2, $A_3 = 0.317$, and $A_4 = 0.279$, then the total line intensity is $I_2 = 3.498 A_0 A_2$. If we instead substitute the NIS-1 parameters $A_3 = 0.8$, $A_4 = 1.0$, then the total line intensity is given by $I_1 = 6.420 A_0 A_2$.

The full-width-half-maximum of a broadened Gaussian profile is not so easy to calculate. However, it can be estimated that the width of an NIS-2 line profile is $2.604 A_2$, and the width of an NIS-1 line profile is $3.935 A_2$.



(a)



(b)

Figure 2: Demonstration of fits of broadened Gaussian line profiles to post-recovery data, for (a) NIS-1, and (b) NIS-2. The symbols in each plot are the measured data, and the line is the fitted data.