

10.7: Instrumental Broadening

Even if the radiation damping profile of a line is negligible and if it is subject to negligible thermal, pressure and rotational broadening, it still has to suffer the indignity of instrumental broadening. Almost any type of spectrograph will broaden a line. The broadening produced by a prism is inversely proportional to the size of the prism, and the broadening produced by a grating is inversely proportional to the number of grooves in the grating. After a spectrum is produced (and broadened) by a spectrograph, it may be scanned by a further instrument such as a microphotometer, or even if it is recorded digitally, it is still further broadened by the point spread function. The instrumental broadening can in principle be determined experimentally by measuring the instrumentally-produced profile of an intrinsically very narrow line. Then, when the instrument is used to examine a broad line, the observed profile is the [convolution](#) of the true profile and the instrumental profile. We can write this symbolically as

$$O = T * I. \quad (10.7.1)$$

Here O , T and I are respectively the observed, true and instrumental profiles, and the asterisk denotes the convolution. The mathematical problem is to deconvolve this equation so that, given the instrumental profile and the observed profile it is possible to recover the true profile. This is done by making use of a mathematical theorem known as **Borel's theorem**, which is that the Fourier transform of the convolution of two functions is equal to the product of the Fourier transforms of each. That is

$$\bar{O} = \bar{T} \times \bar{I}, \quad (10.7.2)$$

where the bar denotes the Fourier transform. Numerical fast Fourier transform computer programs are now readily available, so the procedure is to calculate the Fourier transforms of the observed and instrumental profile, divide the former by the latter to obtain \bar{T} , and then calculate the inverse Fourier transform to obtain the true profile. This procedure is well known in radio astronomy, in which the observed map of a sky region is the convolution of the true map with the beam of the radio telescope, though, unlike the one-dimensional spectroscopic problem the corresponding radio astronomy problem is two-dimensional.

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