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Reply to "Comment on 'Atomic spectral line free-parameter deconvolution procedure'"

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Comment on "Atomic spectral line-free parameter deconvolution procedure"

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Recently Milosavljević and Poparić [Phys. Rev. E **63**, 036404 (2001)] proposed a method for the deconvolution of isolated asymmetric plasma broadened atomic (neutral) spectral lines. The authors claim that their method enables a complete plasma diagnostics by applying this deconvolution on a single experimental line profile. In the present Comment the proposed deconvolution procedure and its application are reexamined.

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In a recent paper [1] a plasma-broadened spectral line deconvolution procedure has been proposed. The authors [1] claim that (1) complete plasma diagnostics can be achieved by fitting a single isolated nonhydrogenic line profile without any additional measurement or prior knowledge/assumptions on the plasma conditions; and (2) all broadening parameters may be determined self-consistently and directly from the line profile with minimal assumptions and without prior knowledge of the plasma conditions.

In the present comment we show the following: (i) Factors not included in the modeling of Ref. [1], such as noise, reabsorption, turbulence, ion dynamics, etc., may be important in practical applications. (ii) Even in the absence of such factors, not all parameters may be accurately obtainable by the deconvolution. (iii) In practice it is in general not at all trivial to check the assumptions spelled out by the authors of Ref. [1] as method requirements, and this is a significant practical difficulty in using the method. In particular, it is our firm conviction that complete plasma diagnostics from a single line profile is not possible without extensive experimental testing. (iv) Some difficulties with the proposed numerical procedure may be encountered. We also comment on the test cases presented in Ref. [1].

In the Comment, as in Ref. [1], only Stark and Doppler broadenings are considered (instrumental broadening may be included in the Doppler broadening, if it has a Gaussian profile). As in Ref. [1], the Stark profile of an isolated nonhydrogenic atomic line is described in Refs. [2,3]:

$$j_{A,R}(x)=\frac{1}{\pi}\int_0^\infty \frac{W_R(\beta)d\beta}{1+(x-A^{4/3}\beta^2)^2}. \tag{1}$$

In Eq. (1), $x=(\lambda-\lambda_0-d_{se})/w_{se}$, where d_{se} and w_{se} are the electron impact shift and width, respectively. The electric microfield distribution $W_R(\beta)$ depends on R, the ratio of the mean interionic distance to the Debye length, and the normalized field strength β. A denotes the static ion broadening parameter. The addition of Doppler broadening results, under the common assumption of statistical independence of the two broadening mechanisms, in a final profile K given by

$$K(x)=\int_{-\infty}^{\infty} G(x-y)S(y)dy. \tag{2}$$

It is assumed in Ref. [1] as well as in the Comment that the experimental profile has the form given by Eq. (2). Coming to our first point, the authors of Ref. [1] claim that the method can extract information from both laboratory and astrophysical plasmas. We should point out that this is not so simple, because laboratory plasmas are often much noisier than the test case they consider, and light from astrophysical sources is always distorted by other broadening mechanisms as well as radiative transfer.

We must also point out that even assuming no such other broadening mechanisms, the accuracy of the fitted parameters may be questionable. In the example [3], the Doppler accuracy is of very minor importance in the determination of the Stark broadening parameters, as Stark broadening dominates. Thus, if one uses the fitted W_G to obtain a Doppler temperature, this will not be very accurate. Furthermore, if this Doppler temperature is used as the electron temperature T_e in R (assuming all temperatures equal) to determine the electron density N_e, N_e may also involve a substantial error. Such issues have been studied in the literature, for example (within a different setting), in Refs. [4] and [5]. Conversely, if Doppler broadening dominates, the accuracy in the determination of Stark broadening parameters may be limited. Similarly, determining N_e from R or w_{se} may well depend on the relative importance on ion vs electron broadening. If ion broadening is important and R is accurately determined, then a knowledge of the temperature yields the electron density, which in principle should match with the N_e and T_e corresponding to w_{se} and d_{se} (clearly R, w_{se}, W_G are not independent as they all depend on density and temperature). As the authors of Ref. [1] mention, it is only very recently that we have seen some important theoretical breakthroughs in the impact broadening of ion lines and reliable tables of electron impact widths are not yet widely available [6,7]. This is presumably why they only used R to determine N_e in both examples given. However, for the Ar I 430.0-nm line, the ion broadening parameter is small and impact broadening dominates, raising concerns as to the accuracy of R. It would be interesting to compare N_e and T_e from various best fitted parameters (in this case w_{se}, being dominant, should be the most accurately determined).

Another important issue is that in the example of the Ar I 430.01-nm line (Fig. 1 in Ref. [3]), N_e was determined from the H_β linewidth and T_e from the plasma composition data [3]. This method of T_e determination implies the equality of the electron and heavy particle (Ar) temperatures. The very

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same assumption, $T_e = T_n$, with T_n the temperature of argon atoms, is used in Ref. [1] to determine N_e and T_e from fitted values of W_G and R via Eqs. (2.3) and (2.7). This is a further assumption that must be checked experimentally or else assumed. Similarly, in Fig. 3 of Ref. [1] the same assumption $T_e = T_n$ is used to determine N_e and T_e. This assumption is here probably justified, due to the relatively high N_e. However, the fitting curve of Fig. 3 of Ref. [1] does not resemble a K profile as in Figs. 1 and 2 of Ref. [1]. No explanation of this point is given in Ref. [1].

Finally, the authors of Ref. [1] introduce an artificial weighing of the off-diagonal Jacobian elements. This does not guarantee the positive-definiteness of the Jacobian matrix [8,9], and consequently the stability and reproducibility of the iterative procedure may become questionable. For more details, see Refs. [10–12].

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