Multicomponent line profile restoring by means of ill-posed inverse task solution

G Revalde[1,3], N Zorina[1,2], A Skudra[2]

[1]Ventspils University College, Inzenieru str. 101, Ventspils, Latvia;
[2] Institute of Atomic Physics and Spectroscopy, University of Latvia, Skunu str. 4, Riga, Latvia;
[3]Institute of Technical Physics, Faculty of Materials Science and Applied Chemistry, Riga, Technical university, P.Valdena 3, Riga, Latvia

E-mail: gitar@latnet.lv

Abstract. The investigation of the criteria of usage of the Tikhonov regularization method for multicomponent overlapping line profiles restoring was done by means of model task solution. The influence of the width and kind of the instrumental function, number of the components of the profile and distance between components are discussed.

1. Introduction

The procedure of restoration of the spectral line profiles from the measured ones is ill-posed task. The small experimental uncertainties can cause large deviations in the solution. In general, for obtaining the real shape of the spectral line, two main directions of solution exist: there are modelling [1] of the spectral line profiles and the real shape obtaining by means of ill-posed inverse task solution.

In this work the "experimental" profiles were modeled by means of a nonlinear multiparameter χ^2 in the first stage. The values of the parameters were chosen so, that the "experimental" model profiles were maximally close to real spectral profiles, emitted from microsizes light sources[2]. After that the solution of the Fredholm integral equation of the first kind was performed to remove the instrumental function by means of Tikhonov regularization.[in detail in[3]]

2. Results and discussion

Below we can see the examples of our calculations. On the figures 1(a-b), we can see comparisons between "modeled -real" profiles and "calculated- real" profiles. "Modeled" profiles with one component were generated with following parameters: Doppler width (FWHM), $\delta\nu D=0.03cm^{-1}$, and Lorentz width, $\delta\nu_L=0.01cm^{-1}$, instrumental function, Gauss profile, $\delta\nu_{Instr.}=0.06cm^{-1}$. For modeling of profile with self absorption were used optical density in the line centre: $k_o l=4$ and homogeneity of the radiation source, n=13. The multicomponent profiles were generated with instrumental function, Gauss profile, $\delta\nu_{Instr.}=0.04cm^{-1}$ (figures 2(a),(b)) and $\delta\nu_{Instr.}=0.06cm^{-1}$(figure 2(c)). The distances between components $0.1cm^{-1}$ (figures 2(a), (c)) and $0.3cm^{-1}$ (figure 2(b)).

As we can see on the figures 1(a-b) and 2(a-c), there are very well coincidence between "modeled - real" profile and "calculated- real" profiles as for one component(figures 1(a-b)) as well for multicomponents profiles (figures 2(a-c)).

Content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.
Published under licence by IOP Publishing Ltd

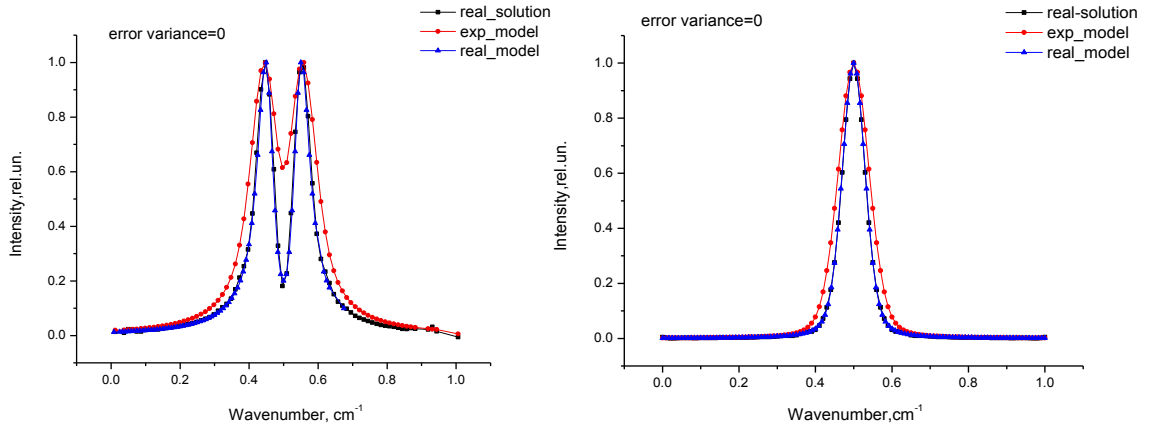
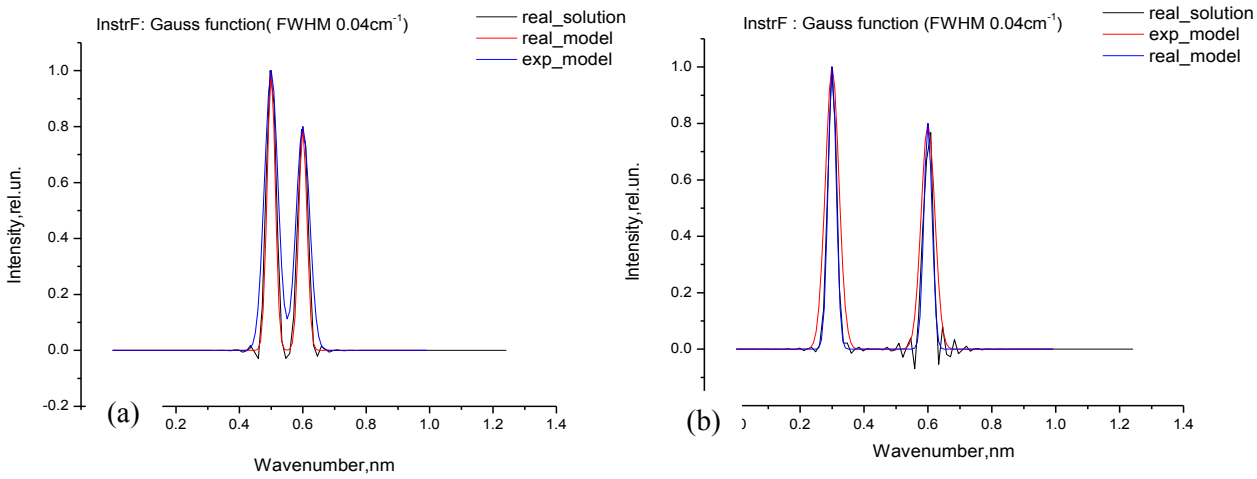


Figure 1. Comparison between "Real modeled" (modeled by means of non-linear multi-parameter modelling) one component profile and "Real solution" profile(obtained by means of Tikhonov regularization method). (a)initial profile was generated with self absorption; (b) initial profile was generated without self absorption.



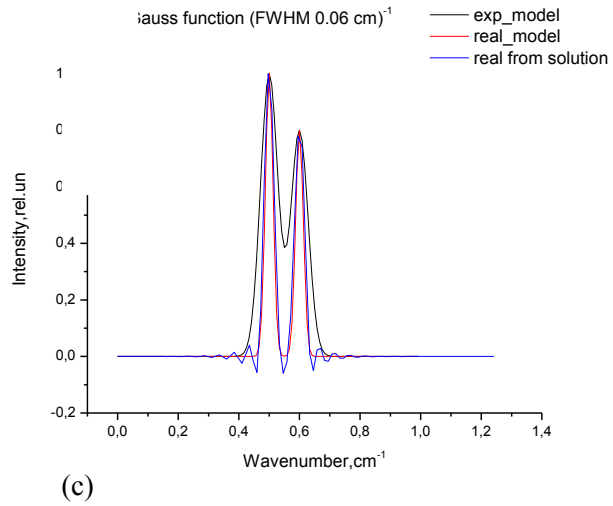


Figure 2. Comparison between "Real modeled" (modeled by means of non-linear multi-parameter modelling) multicomponent profile and "Real solution" profile(obtained by means of Tikhonov regularization method). Instrumental function is Gauss function.

On the figures 3(a-d) we can see results, obtained for cases when was used absolutely different instrumental function. The instrumental function was given as data massive (Airy function).

The mirrors refraction coefficients are: 0.6, 0.7, 08 and 0.9 accordingly. "Experimental" profile was generated without errors. As we can see, too broad instrumental function (refraction coefficient is 60%) leads to the errors in the solution.

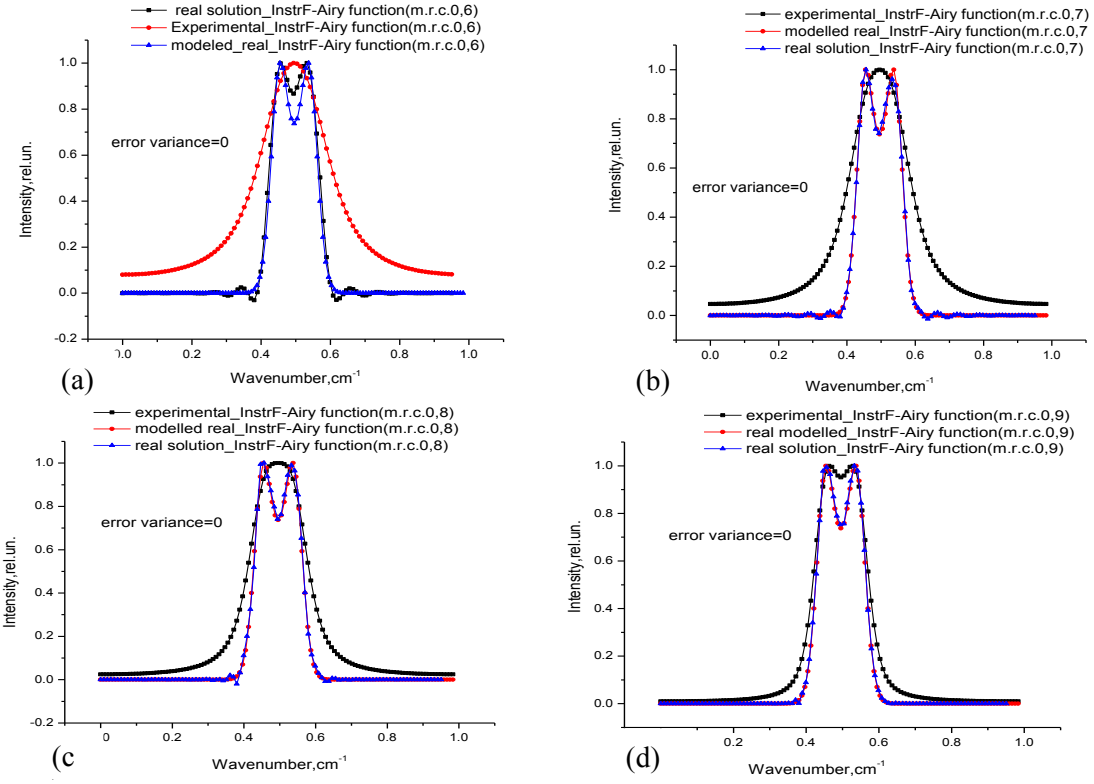


Figure 3. Comparison between "Real modeled" (modeled by means of non-linear multi-parameter modelling)profile and "Real solution" profile(obtained by means of Tikhonov regularization method). Mirrors refraction coefficients are: (a)= 60%,(b)= 70%, (c)= 80%,(d)= 90%. Instrumental function is Airy function.

3. Conclusion

As we can see FWHM of „calculated real" profiles and dip of self absorption coincide with „modelled real" profiles very well as for profiles with one component as well as for multicomponent profiles. This is true, in error limit, for both cases, when the instrumental function was used as formula and as data massive and independent on kind of instrumental function. All this work results show, that instrument function has not been neglected in case of low –pressure or cold plasma: when the instrument function is on the same order that experimental profile.

Acknowledgements

This research has been partly supported by the National Research Programme of Latvia"The next generation of information and communication technologies" (NexIT).

References

[1] A. Skudra,G. Revalde, Mathematical modeling of the spectral line profiles in the high-frequency discharge ,1999, *JQSRT* 61, N6, pp 717-728

[2] G. Revalde, N. Zorina, A. Skudra, Z. Gavare, Deconvolution of the line spectra of microsize light sources in the magnetic field, *Romanian Reports in Physics*, Vol. 66, No. 4, P. 1099–1109, 2014

[3] N. Zorina, G. Revalde, R. Disch, *Proceedings of SPIE Sixth International Conference on Advanced Optical Materials and Devices (AOMD-6)*, 24–27August (2008) Riga, Latvia, Vol. 7142 71420J-1