A method for inferring the soot size distribution by Static Light Scattering : Application to the CAST soot generator

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The soot size distribution is often determined by using ex-situ granulometers, after sampling of the particles. But the quenching of aggregation process during the sampling is difficult to control and raises the question of representativeness of the results (Ouf et al. 2010 [1]). For this reason, optical measurements are more suitable. Thanks to the approximation of Rayleigh – Debye – Gans for Fractal Aggregates which is well suitable for such particles, (RDG-FA theory - Dobbins et al., 1991 [2]), measurement of static light scattering (SLS) can be interpreted in order to determine a size parameter called gyration radius. The inversion of experimental data by this theory to infer the gyration radius of monodisperse aggregates has been recently validated (Caumont et al. 2010 [3]).

The SLS technique consists in measuring the signal scattered by the particles after interaction with a polarized laser light (532 nm in our case) at different scattering angles. Since a long time, some authors have proposed to determine a representative gyration radius of the polydisperse population with this optical technique (Dobbins & Megaridis 1991 [2], Köylü 1994 [4]). More recently, inversion methods have been proposed by coupling scattering and extinction measurements (Koylu & Faeth (1996) [4] and Iyer et al. (2007) [5]). But these methods rely on the knowledge of soot optical index which is unfortunately not accurately known. Moreover Burr et al [6] by using Bayes' theorem showed mathematically that the inverse problem is ill-posed..

This work presents a new inversion method for the determination of soot size distribution in flames by measuring scattered light at different angles. It consists in determining for each studied angle, by using the RDG-FA theory, a gyration radius $R_g^*(\theta)$ of a monodisperse population which has the same optical behavior as the real polydisperse population. The so determined $R_g^*(\theta)$ function informs us about polydispersity of soots. The method has been validated by comparing obtained results with size distribution determined by Transmission Electron Microscopy (TEM). The method is now applied to characterize soot size distribution generated by the Jing CAST apparatus that is suspected to become a standard for soot generation including for LII calibration. Results are compared with soot size distribution determined by DMS500 apparatus.

[1] Ouf, F.X., Yon, J., Ausset, P., Coppalle, A. Maillé, M. Aerosol Sci. Technol., 44, (11), 1005-1017. (2010).
[2] Dobbins, R.A., Megaridis, CM, Applied Optics, 30 (33), 4747-4754 (1991).
[3] Caumont, C., Yon, J., Ren, K.-F., Coppalle, A. Proc. 26ième Congrès Français sur les Aérosols, Paris, France (2011).
[4] Köylü, Ü, Ö, Combustion and flame, 109, 488-500(1997).
[5] Iyer S. S., Litzinger, T. A., Lee, S-Y, Santoro R. J., Combustion and flame, 149 (1-2), 206-216 (2007).
[6] D.W. Burr, K.J. Daun, O. Link, K.A. Thomson, G.J. Smallwood, Journal of Quantitative Spectroscopy and Radiative Transfer, Vol. 112, Issue 6, pp. 1099-1107, (2010)