EUROPEAN SYNCHROTRON RADIATION FACILITY

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ESRF

ESRF	**Experiment title:** Two temperature theory: an experimental test	**Experiment number**: HD-306
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Report:

Inelastic X-ray Scattering (IXS) data from $He_{0.8}Ne_{0.2}$ gaseous mixtures were collected at different thermodynamic points and momentum transfer (Q) ranges: (i) T = 44 K and P = 400 bar for $Q \in [10 - 25]$ nm^{-1}; (ii) T = 82 K and P = 320 bar for $Q \in [8 - 43]$ nm^{-1}; (iii) T = 184 K and P = 410 bar for $Q \in [8 - 52]$ nm^{-1}. The lower-Q's spectra were performed at an incident photon energy E_i = 21.747 keV, using the silicon (11,11,11) set-up, providing an overall energy resolution E_R = 1.5 meV (FWHM). The higher-Q's spectra were, instead, acquired at E_i = 17.794 keV, exploiting the silicon (9,9,9) set-up, with E_R = 2.9 meV. The momentum resolution (ΔQ), defined by the aperture of the analyzer slits, was set at 0.3 nm^{-1} for the low-Q measurements and at 1 nm^{-1} for the high-Q data, i.e. the analyzer slits was completely open. This latter configuration permitted to increase the count rate. Indeed, a better Q resolution is not needed at high-Q, while it's needed to compensate for the rather strong reduction in the intensity of scattered signal due to the high-Q decrease of form factor, to the decrease of the polarization factor at large scattering angle and to the decrease in the deep of field of the spectrometer at high angles. The chosen E-range was quite large (± 50 meV), the E-sampling steps quite narrow (~0.3meV) and the acquisition time for each E-point quite long (a few minutes) in order to obtain high quality and high statistics data. For each experimental configuration the experimental resolution curve, $R(\omega)$, has been measured. IXS data from pure He at T = 184 K and P = 320 bar (i.e. at the same T and the same density of He into the He/Ne mixture) were collected as well. We used the standard large volume (~0.7 cm^3) high-pressure hydrostatic cell available at ID16/ID28 beamlines. The measured contribution of the empty cell to the signal is negligible.

In the case of the He/Ne mixture at T = 184 K and $Q \in [18 - 52]$ nm^{-1} the Impulse Approximation (IA) holds. In this Q range the dynamical structure factor S(Q,ω) can be described by a summation of two Gaussian functions related to the momentum distribution of He and Ne particles respectively. The data have been fitted exploiting a fit function given by the described model function of S(Q,ω) convoluted with R(ω) (Fig. 1). The extrapolated values of the square of He and Ne Gaussian's variance, $\sigma^2_{He}(Q)$ and $\sigma^2_{Ne}(Q)$ respectively, are shown in Fig. 2. The black solid line is the ideal gas behavior of $\sigma^2(Q)$ calculated assuming a Maxwell distribution where T is fixed to the thermodynamic equilibrium value of 184 K. The green solid lines represent their values where final state corrections are considered. The red solid line is a linear interpolation. For the subsystem of Ne particles, the value of σ(Q) calculated assuming a Maxwell distribution characterized by the equilibrium temperature T and taking into account final state corrections fit enough accurately the σ(Q) data in all the probed Q range. In the case of the He subsystem, conversely, it is observed an anomalous behavior of σ(Q) for $Q>30nm^{-1}$. Its value is, in fact, systematically higher than that one estimated by a Maxwell distribution function with temperature T. In order to fit experimental data a Maxwell distribution function with T = 220 ± 10 K, i.e ~ 40 K higher than the macroscopic one, has to be supposed. This result can be interpreted in the framework of two-temperature theory for disparate mass binary mixtures [1] and calls for further investigation.

The lower-Q data have been analyzed trough an ad-hoc generalization of the viscoelastic model to bynary systems, for the first used to this aim, as described in [2].

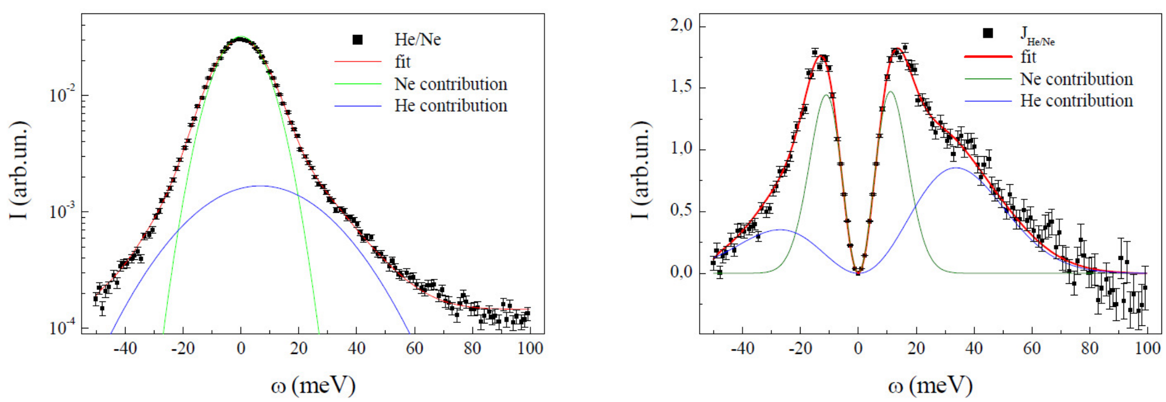

Fig. 1 Left graph: IXS spectrum at Q = 41nm^{-1} of $He_{0.8}Ne_{0.2}$ mixture at T = 184K (black circles) with the best fit curve (red line). Right graph: corresponding $J(Q,\omega) = \omega^2 S(Q,\omega)$. The He contribution is more evident.

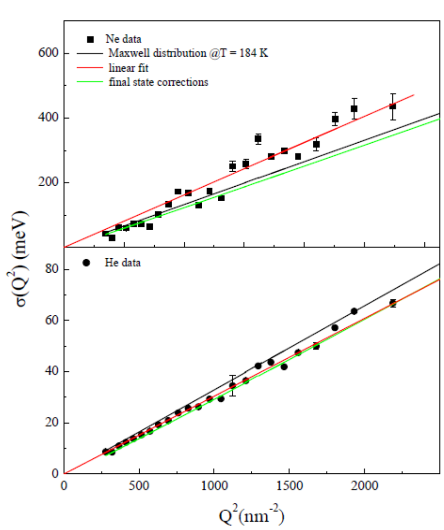

Fig. 2 σ(Q) of He and Ne as a function of Q^2.

[1] Bonatto J.R. and Marques Jr., J. Stat. Mech. **9**, 09014 (2005)
[2] M. G. Izzo, F. Bencivenga, A. Cunsolo, A. Gessini and C. Masciovecchio "A viscoelastic analysis of IXS spectra from He/Ne mixtures", Phil. Mag., accepted for publication.