GLOBAL RAINBOW THERMOMETRY DEVELOPMENT AND APPLICATION TO EVAPORATION AND DIFFUSION PROCESSES

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At the present time the Rainbow Thermometry represents a significant powerful experimental technique for droplets diagnostics, especially for two-phase flows. The study of the thermal and hydrodynamic characteristics of two-phase flows, as sprays, is of a primary importance in many engineering designs and industrial applications. Sprays are encountered in dryer systems for the production of microcapsules and powders, frequently in the medical field, in agriculture to pulverize chemical products and as gas scrubbers for absorbing specific species. In combustion, sprays are used to vaporize the liquid fuel in very small particles in the ignition chamber to facilitate the burning efficiency. Sprays are also arranged in curtains for the mitigation of the consequences of accidental release of hazardous gases and for the fire protection of storage tanks. All the aforementioned applications require a good knowledge of the droplet characteristics to achieve relevant modelling of transport phenomena in the sprays. Nowadays several measurement techniques exist to measure the physical properties (e.g. size or velocity) of liquid droplets.

The GRT technique is able to determine the size and the temperature mean value and the dispersion factor of the droplets constituting a spray. The GRT technique is based on the analysis of the interference fringe image generated by an ensemble of particles, immersed in an environment with a lower refractive index (e.g. air), illuminated by a monochromatic laser light. The distance between two fringes and the absolute angular position of the interference image in the space give respectively information on the droplet size and temperature.

The purposes of this research activity are multiples. The first one is to give a complete review of the state of the art about the rainbow and then to show how this natural phenomenon can be used in physics as a diagnostic tool. Then the scope is to describe the personal contribution to rainbow thermometry research either theoretically, with the extension of the rainbow theory to non-homogeneous particles, and experimentally with the application of the GRT technique to liquid-liquid suspensions and to particular two-phase flows (e. g. spray) in isothermal and non-isothermal conditions.
The most important results obtained during the first three years of this activity research are the followings:

1. An innovative data inversion algorithm that takes into account the complete interference fringe image and that is able to give information on the particle non-sphericity has been formulated.

2. The GRT technique has been applied and validated on a liquid-liquid suspension using the new data inversion algorithm. The results coming out from this study has been published in 2004 by the scientific journal ***Applied Optics***

3. The GRT technique has been applied to sprays in non-isothermal conditions. In particular the characterisation of a flat fan water spray in non-isothermal conditions has been performed. Moreover the GRT measurements are compared to numerical simulations with satisfactory agreement. The results coming out from this study has been published in 2005 by the scientific journal ***Experiments in Fluids***

4. An extension of the Airy theory to spheres featuring an internal gradient of refractive index has been formulated. The particular case of burning droplets is considered as an example for and the results obtained are successfully compared with the ones presented in literature. The results coming out from this study has been published in 2005 by the scientific journal ***Optics Letters***

5. Exploiting the generalization of the Airy theory, a data inversion algorithm for single droplet, presenting a parabolic refractive index gradient, is proposed. This data inversion algorithm is used to compute the diameter and the refractive index at the core and at the surface of a simulated burning droplet. The results are compared to the analytical solutions showing a satisfactory agreement. The results coming out from this study has been published in 2005 by the scientific journal ***Applied Optics***