Chair: Physics of Fluids group

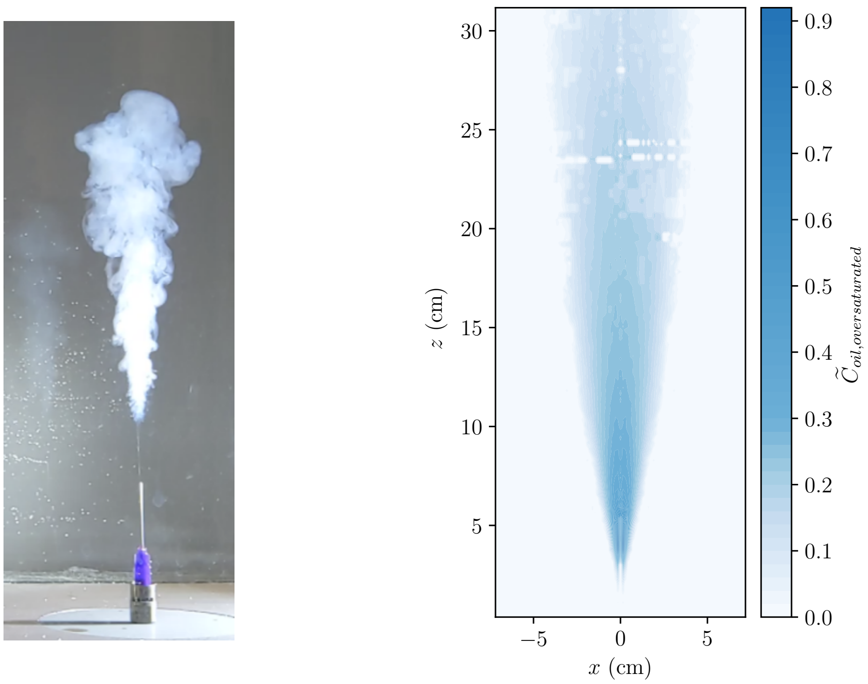
Ouzo effect in turbulent jets and plumes

Description

In this assignment we will work with a fluidic system based on the Greek alcoholic beverage ouzo. Ouzo is known (fluid-dynamically) for it's so-called ouzo effect which causes the generation of micron-sized droplets in a three-component liquid. Taking the ouzo beverage as example, the system consists of water, ethanol, and anise oil. While anise oil is miscible in ethanol, adding water will cause micron-size oil droplets to nucleate out of the solution, creating a milky appearance. This process finds various industrial application, such as liquid-liquid extraction and drug delivery [1]. While the ouzo effect has attracted many scientific interests in recent years, the scope of quantitative understanding is limited to small scales and laminar flow, *e.g.* in microfluidic setups [2]. It is therefore highly valuable to extend this line of research into the (mildly) turbulent regime.

Turbulent jet and plume is one of the most fundamental type of turbulent shear flow, and serves as a perfect platform to study multicomponent, multiphase flows, which are commonly seen in nature [3]. However, the opaque nature of a flow displaying the ouzo effect (see Fig. 1a) makes it difficult to measure the oil concentration in the jet by the commonly used laser-induced fluorescence method. We have developed an experimental method to measure the concentration using a light attenuation technique, obtaining concentration field as in Fig. 1b. With droplet nucleation, the flow profile of the ouzo jet is significantly different from the traditional jet flow.

For a thorough understanding of the phenomena, it is important to conduct the experiments for a broad range of Reynolds number and initial composition of the injected fluid mixture. Also, the injecting direction of the jet can notably affect its dynamics, which results from the competition between buoyancy and momentum [4]. Such competition will in turn determine the strength of turbulent entrainment, which is the driving mechanism for the droplet nucleation in the ouzo jet flow. Hence, it is interesting to study the effect of injecting direction on the flow profile.



(a) (b)

Figure 1: Converting recorded image in (a) to concentration field in (b)

Assignment

We will conduct experiments in the setup shown in Fig. 2. The mixture of ethanol and anise oil of specific compositions will be injected into a tank filled with water, forming the milky ouzo jet. The injection speed and thus initial Reynolds number can be controlled by the syringe pump. The injection direction can be varied by the placement of the needle. We will employ a light attenuation technique and an optimization algorithm to measure the mean concentration field. This work will extend the knowledge on ouzo effect into the turbulent regime, and broaden the scope of multicomponent, multiphase turbulent jets with phase transitions.

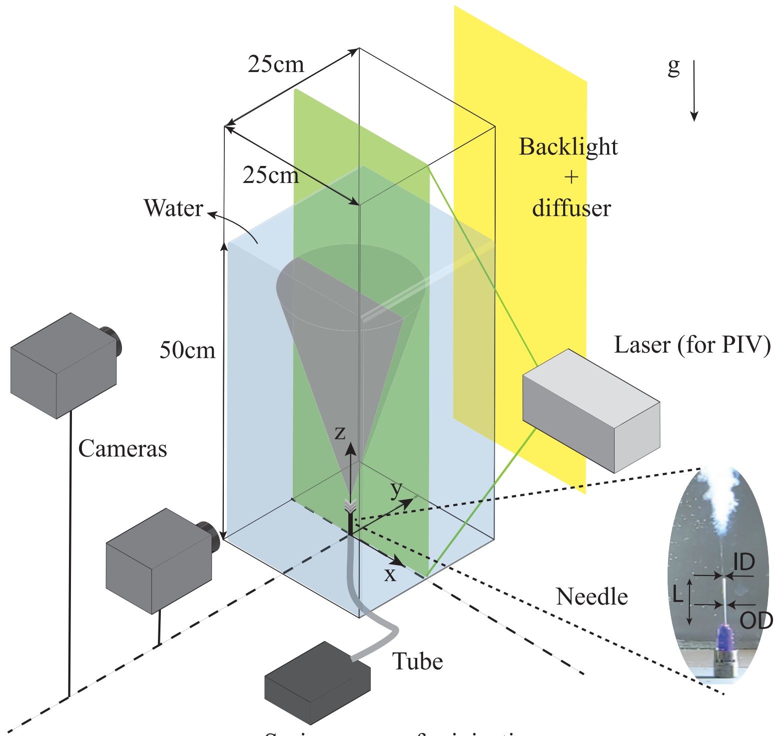


Figure 2: Experimental setup. The inset shows the photo of the needle for injection. Note that the laser was only activated for PIV.

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