INTRODUCTION

The most important probe to study the systems and their dynamics is the electromagnetic radiation. For instance until the last two decades any knowledge of the universe had been obtained through processing of its visible or non visible light. In the labs, where the experiments can be prepared, numerous investigations are based on interaction of light with matter. Some of them give visualization, others, such as absorption of ultraviolet, visible and infrared radiation provide detailed informations on energy levels of molecules and atoms. Here our aim will be to present how scattering of light provides many solutions for measuring physical quantities like velocity, temperature, concentration, their mean values as well as their fluctuations in flows with applications to an interesting reactive flow: combustion. Due to the importance of the subject we have been led to restrict the lectures to some aspects of optical diagnostics. This course concentrates on elastic and quasi elastic light scattering. Very important topics like Raman and coherent antistokes Raman scattering, Laser Induced fluorescence and a recent promising technique, the optogalvanic spectroscopy which give instantaneous and local informations on temperature and concentration will not deal with here. As a first approach of the latter subjects we suggest the reading of "Laser probes for Combustion Chemistry" edited by D.R. Grosley. Today combustion science is considered from two convergent points of view. On one hand, physicists are able to give sophisticated models where the mechanisms of combustion (i.e. diffusion processes and chemical reactions) are taken into account as well as the hydrodynamics. On the other hand, the evolution of aircraft gas turbine combustion technology over the past forty years...
has been extremely impressive and recent developments have caused significant shifts in development emphasis toward combustion technology. For example, in addition to the necessary improvements to increase the thrust/weight ratio, new concepts and technology improvements are necessary to satisfy recent exhaust pollutant regulations. Thus, to check the theories, to give numerical values for numerical simulations or to control the characteristics of an engine, accurate tools have been developed with the advent of the lasers. As a matter of fact most of the relevant information must be obtained by non invasive, local and instantaneous measurements. These needs can be satisfied by using optical techniques and laser sources. Of course most of optical techniques used in hydrodynamics such as flow visualization can be used but specific problems arise in combustion with the existence of large gradients of temperature or concentration. The well-known monograph of F.J. Weinberg "Optics of flames" remains the reference on classical methods. We do also mention the book of R.M. Fristrom and A.A. Westenberg on "Flame structure", which gives a complete view of the techniques applied up to 1965. In the last decade new techniques essentially based upon the laser light scattering have been used successfully. The aim of the present course is to give the general principles of some of these methods. The important literature on laser diagnostics can be found in the proceedings of the International Symposiums of the Combustion Institute, in Combustion and Flame, Applied optics, the proceedings of the AIAA meetings or of the ICOGERS meetings (Progress in astronautics and aeronautics. This list is non exhaustive).

As an introduction to combustion the reader will refer to the lectures of P. Clavin in this volume or in. In the following, without loss of generality we will consider only the problems of the premixed flame. In most cases it can be considered as an hydrodynamic surface of discontinuity which separates the fresh mixture from the burned gases. This surface $\alpha(x,y,t)$ (the flame thickness is very small compared to the wavelength of wrinkles, fig.1) moves with a local velocity $\mathbf{u}(x,y,t)$ in relation to the turbulent velocity field $\mathbf{u}(x,y,t)$. The main measurements to be performed are velocity of gases and flame, temperature and concentrations of different species; all these informations are necessary to build a model of the combustion process, for example in an internal combustion engine. Moreover the structure of the flame i.e. the temperature and concentration profiles are related to the dynamical properties and a knowledge of these characteristics is an important goal. To summarize, table 1 gives a survey of the quantities of interest and the measurement techniques generally used.