VELOCITY VISUALIZATION IN GASEOUS FLOWS

R. K. Hanson, J. C. McDaniel and B. Hiller
Department of Mechanical Engineering
Stanford University
Stanford, California 94305

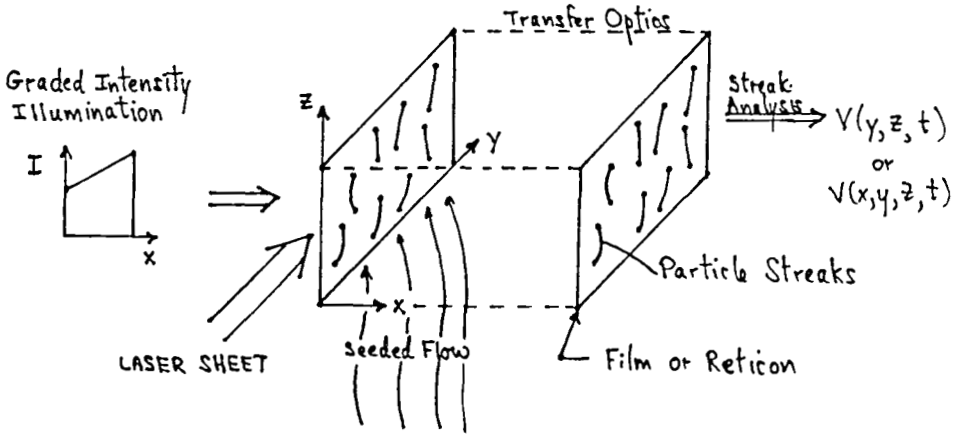
Techniques yielding simultaneous, multiple-point measurements of velocity in reacting or nonreacting flowfields have the potential to significantly impact basic and applied studies of fluid mechanics. This research program is aimed at investigating several candidate schemes which could provide such measurement capability. The concepts under study utilize laser sources (to illuminate a grid, a plane or a volume in the flow) which lead to scattered light (from Mie scattering, fluorescence on chemiluminescence) which can be monitored by a film-based camera or a multi-element solid-state camera (100 × 100 array of photodiodes). Anticipated experiments will be discussed, and recent results for velocity measurements in supersonic flows using a novel Doppler-modulated fluorescence concept will be presented. Related research at Stanford on species visualization sponsored by AFOSR will also be summarized as time permits.

OUTLINE OF PRESENTATION

- MOTIVATION (NEED FOR MULTIPLE-POINT MEASUREMENTS)
- SUMMARY: TECHNIQUES UNDER INVESTIGATION
  - STREAK RECORDING
    - MIE SCATTERING
    - LASER-INDUCED PHOSPHORESCENCE
  - PULSED GRID RECORDING
  - *DOPPLER MODULATED FLUORESCENCE (DMF)
- EXPERIMENTAL RESULTS (DMF)
- RELATED RESULTS FROM AFOSR RESEARCH

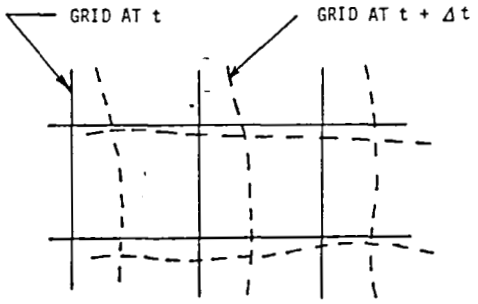
STREAK RECORDING

- SEEDED PARTICLES (DROPS) ARE ILLUMINATED BY CW LASER SHEET
- MIE SCATTERING GIVES STREAKS ON FILM (RETICON)
- GRADED INTENSITY BEAM (TRANSVERSE TO SHEET) GIVES POTENTIAL FOR 3-D RECORDING, IF PARTICLES UNIFORM IN SIZE

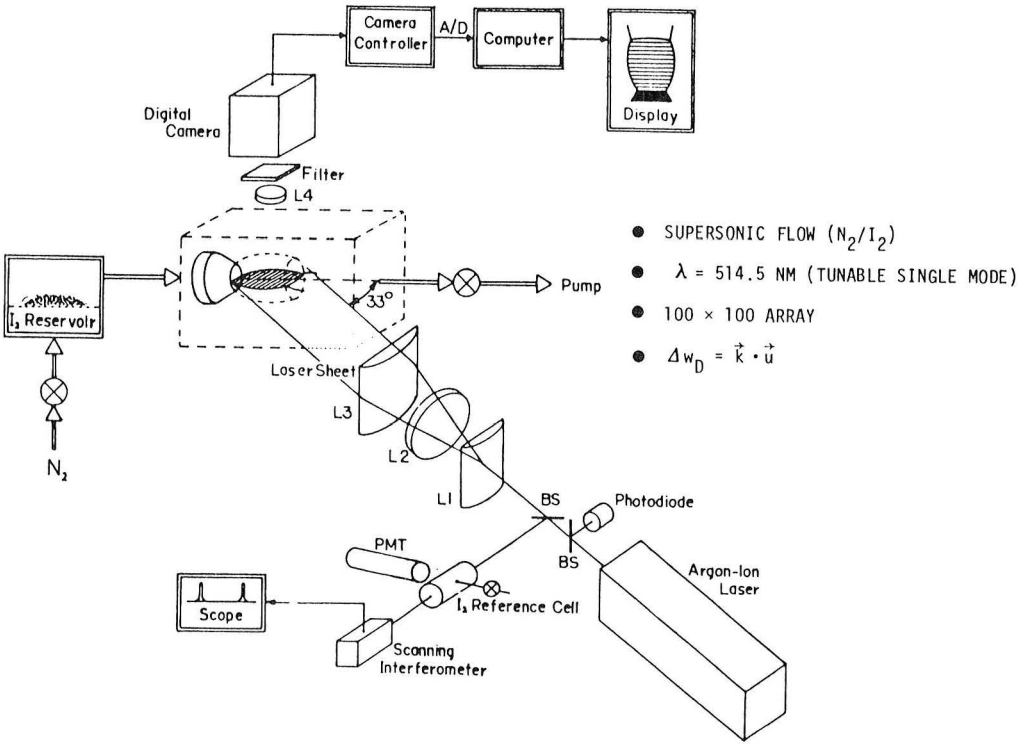


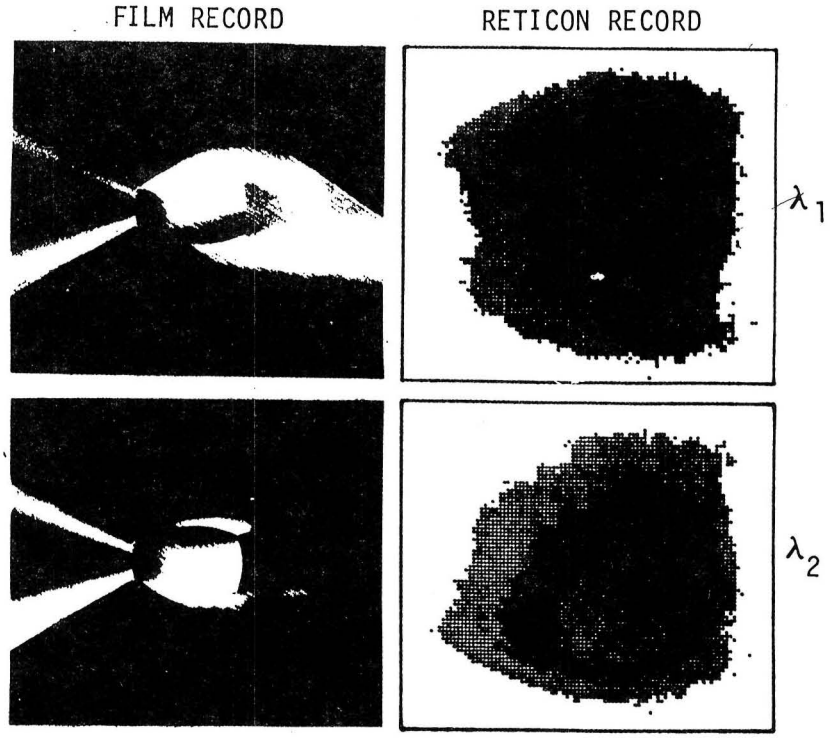
PULSED GRID RECORDING

- A PULSED TUNABLE LASER IS USED TO ILLUMINATE A GRID IN THE FLOWFIELD
- LASER-INDUCED PHOSPHORESCENCE (OR CHEMILUMINESCENCE) PROVIDES LONG-LIVED RADIATION FROM EXCITED FLUID ELEMENTS
- MULTIPLE EXPOSURE OF GRID PATTERNS ARE RECORDED ON A SINGLE FRAME OF RETICON CAMERA (OR FILM)
- CANDIDATE MATERIALS: BIACETYL(DROPLET OR VAPOR)
  NO_2/CO CHEMILUMINESCENCE

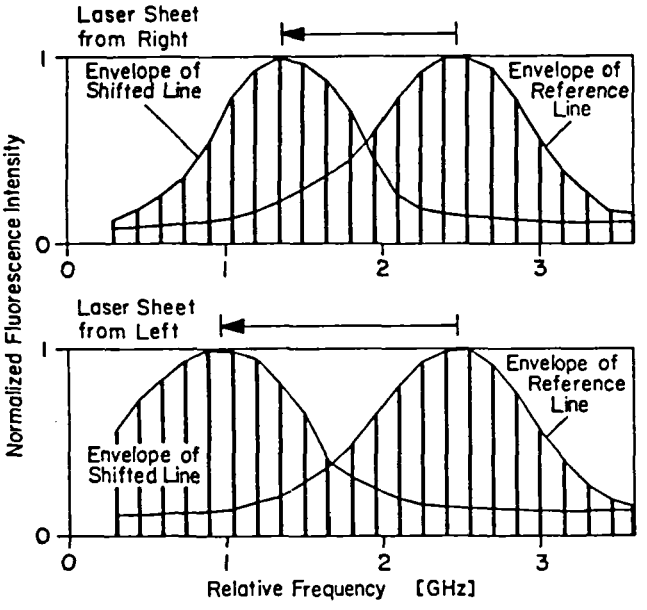


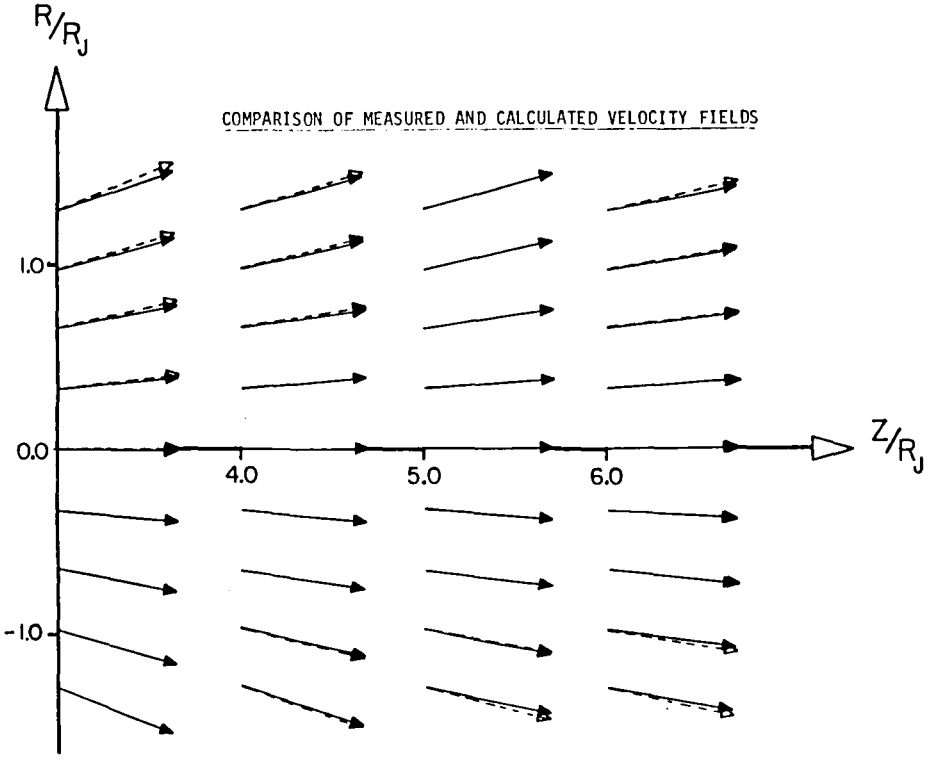
DOPPLER-MODULATED FLUORESCENCE





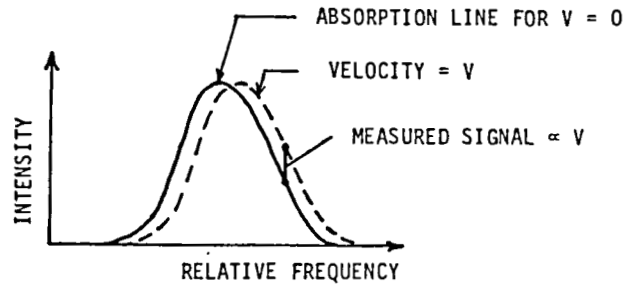
FLUORESCENCE INTENSITY RECORD
FOR AN OFF-AXIS PIXEL





EXTENSION TO SUBSONIC FLOWS

- FIX WAVELENGTH
- MONITOR VARIATION IN INTENSITY TO INFER VELOCITY
- RECORD AT HIGH REPETITION RATE TO DETERMINE $U(x,y,t)$



SUMMARY

DOPPLER-MODULATED FLUORESCENCE

SIGNIFICANCE:	MULTIPLE-POINT MEASUREMENTS IN UNSEEDED FLOW
STATUS:	FIRST GENERATION EXPERIMENTS COMPLETED SUCCESSFULLY USING SCANNING CONCEPT, 1 BEAM, SUPERSONIC FLOW
LIMITATIONS:	LENGTHY RECORDING TIMES LIMITED VELOCITY RESOLUTION (∼ 5 M/SEC)
FUTURE:	DEVELOP SUBSONIC FLOW TECHNIQUE USING FIXED WAVELENGTH, MULTIPLE BEAMS DYE LASER TO OPTIMIZE WAVELENGTH