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NTR PLUME MODELING

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COMPUTATIONAL FLUID DYNAMICS (CFD) FOR PLUME ANALYSIS

MOLECULAR FLUID MECHANICS

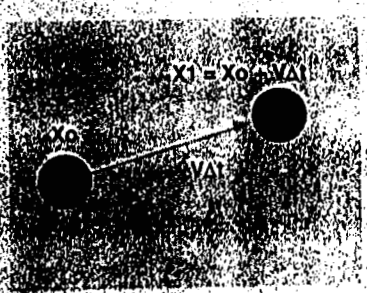
- THE VAST MAJORITY OF CFD DEALS WITH GASES WHICH ARE ADEQUATELY DESCRIBED BY THE CONTINUUM THEORY, I.E., THE NAVIER-STOKES EQUATIONS.
- IN RAREFIED GAS FLOWS, A MOLECULAR MODEL IS APPROPRIATE, REQUIRING DIFFERENT TECHNIQUES.
  - DIRECT SIMULATION MONTE-CARLO (DSMC)
  - FINITE DIFFERENCING OF THE BOLTZMANN EQUATION
- MOLECULAR CFD IS REQUIRED FOR:
  - NOZZLE LIP AND CRITICAL BACKFLOW REGIONS
  - PLUME / SPACECRAFT INTERACTIONS
  - GROUND TESTING

MOLECULAR CFD CHARACTERISTICS

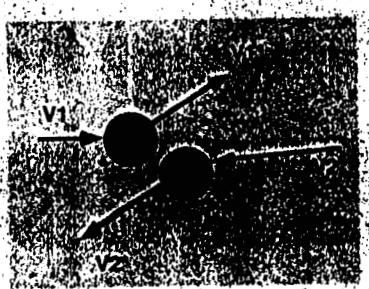
- DSMC TECHNIQUES TRACK A LARGE NUMBER OF MOLECULES (OF ORDER 10^5 TO 10^7) AND MODEL THEIR INTERACTIONS STATISTICALLY.
- COMPUTATIONALLY INTENSIVE
- DR. CHAN-HONG CHUNG HAS DEVELOPED AN ENHANCED DSMC CODE WITH MULTI-SPECIES CAPABILITY, ALLOWING MORE ACCURATE CALCULATIONS OF SPECIE SEPARATION.

DIRECT-SIMULATION MONTE-CARLO (DSMC) METHOD

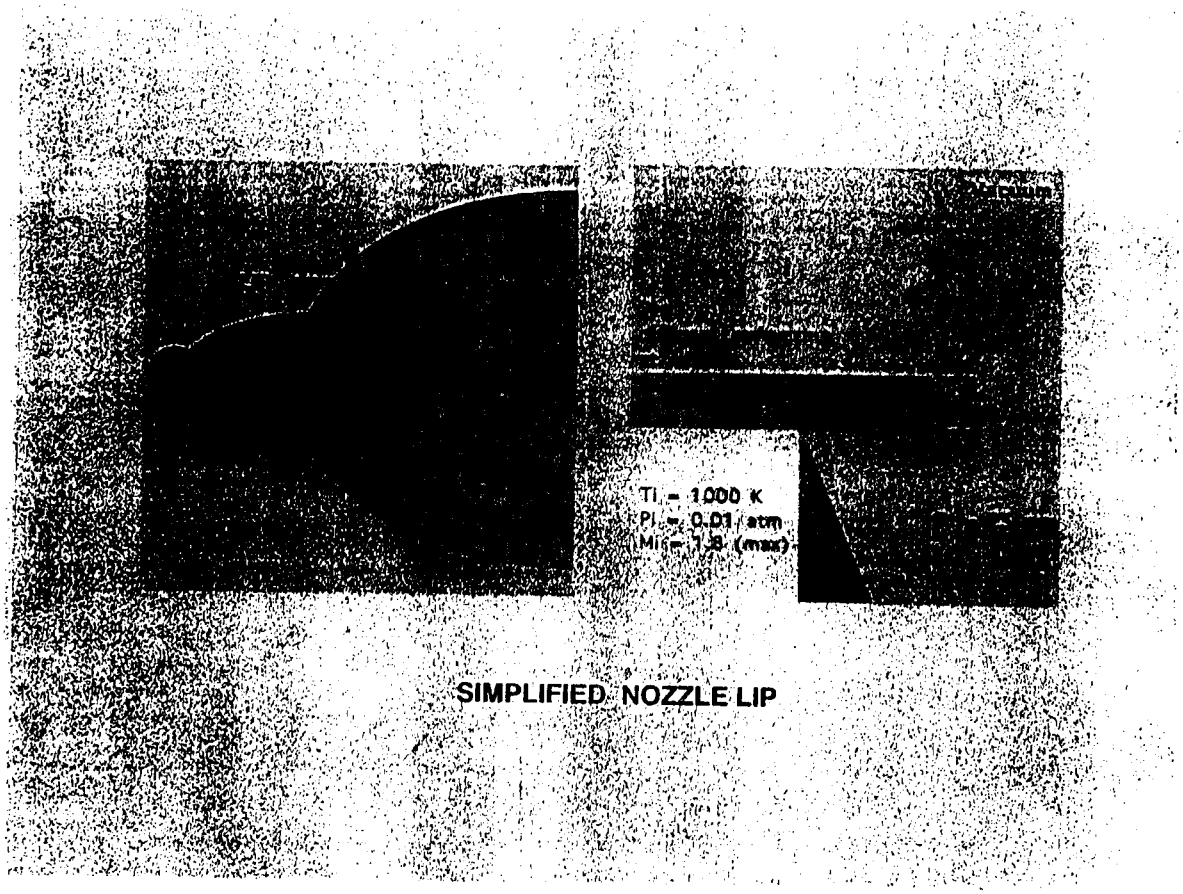
A computer technique to model low density gas flows by concurrently following the motion and intermolecular collisions of representative molecules



Molecular movement



Molecular collision



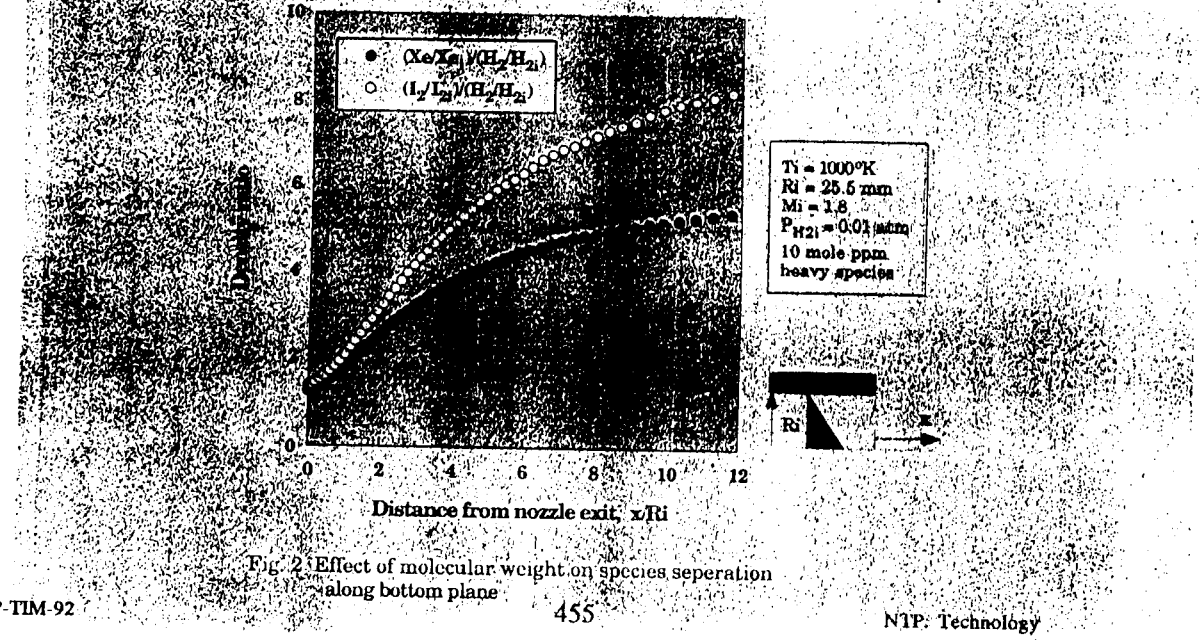
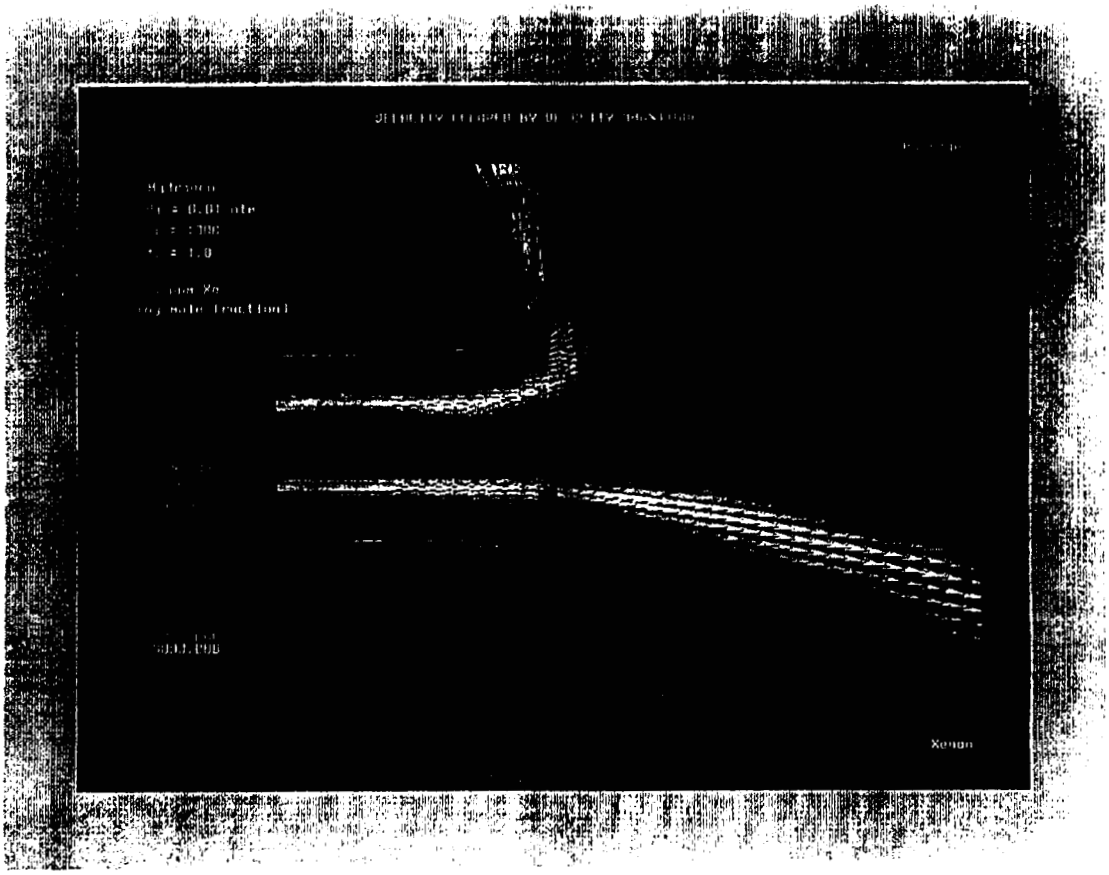


Fig. 2 Effect of molecular weight on species seperation along bottom plane



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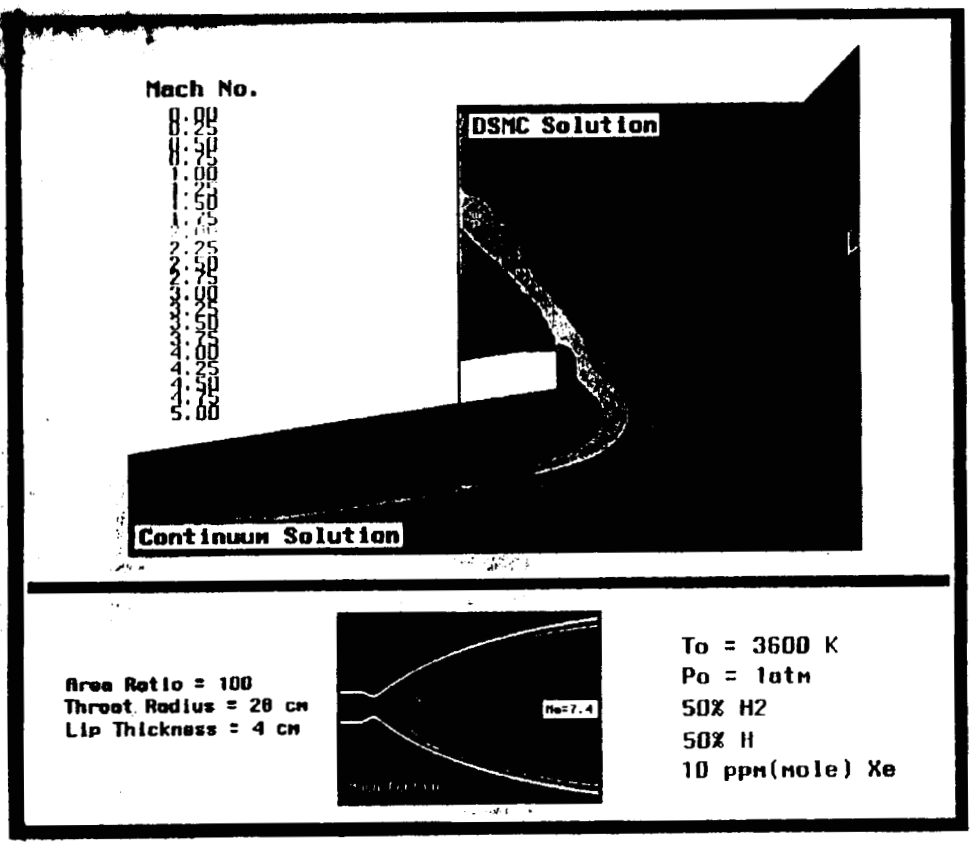
INTEGRATION OF

DSMC AND NAVIER-STOKES COMPUTATIONS



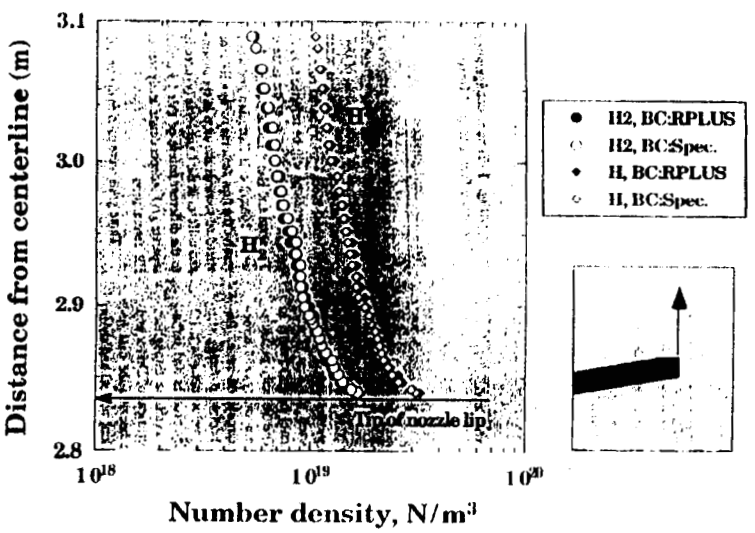
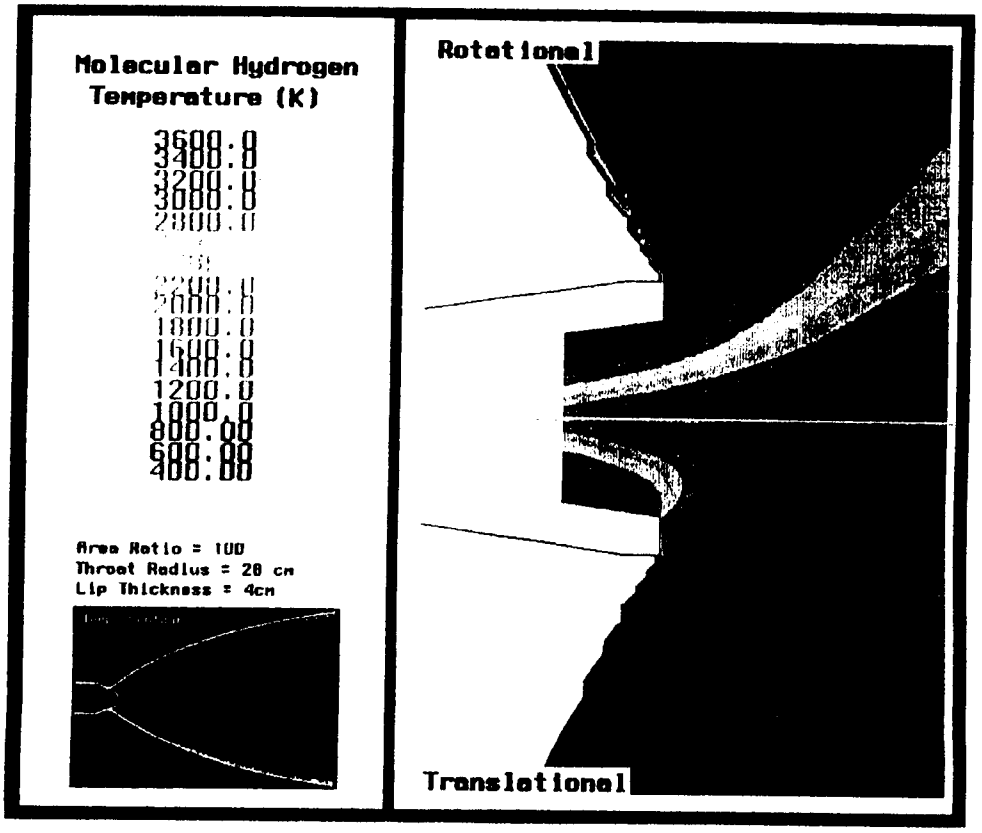


Fig.1 Density profile along the line parallel to exit plane



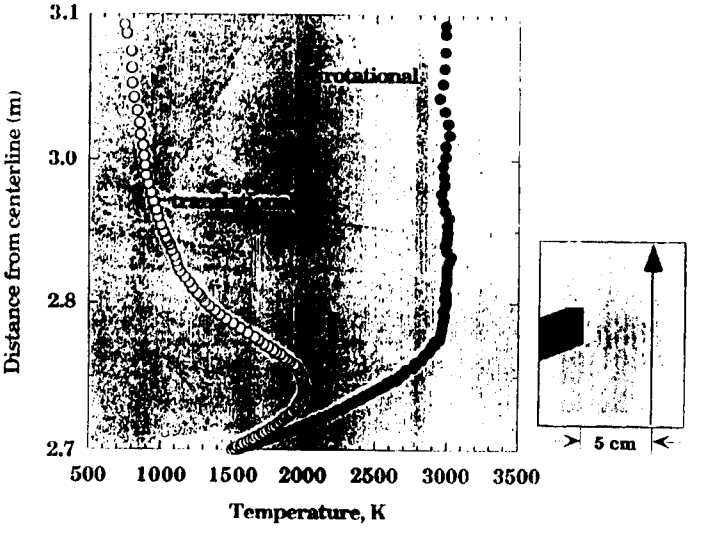


Fig.4 Molecular hydrogen temperature profile along the line parallel to exit plane

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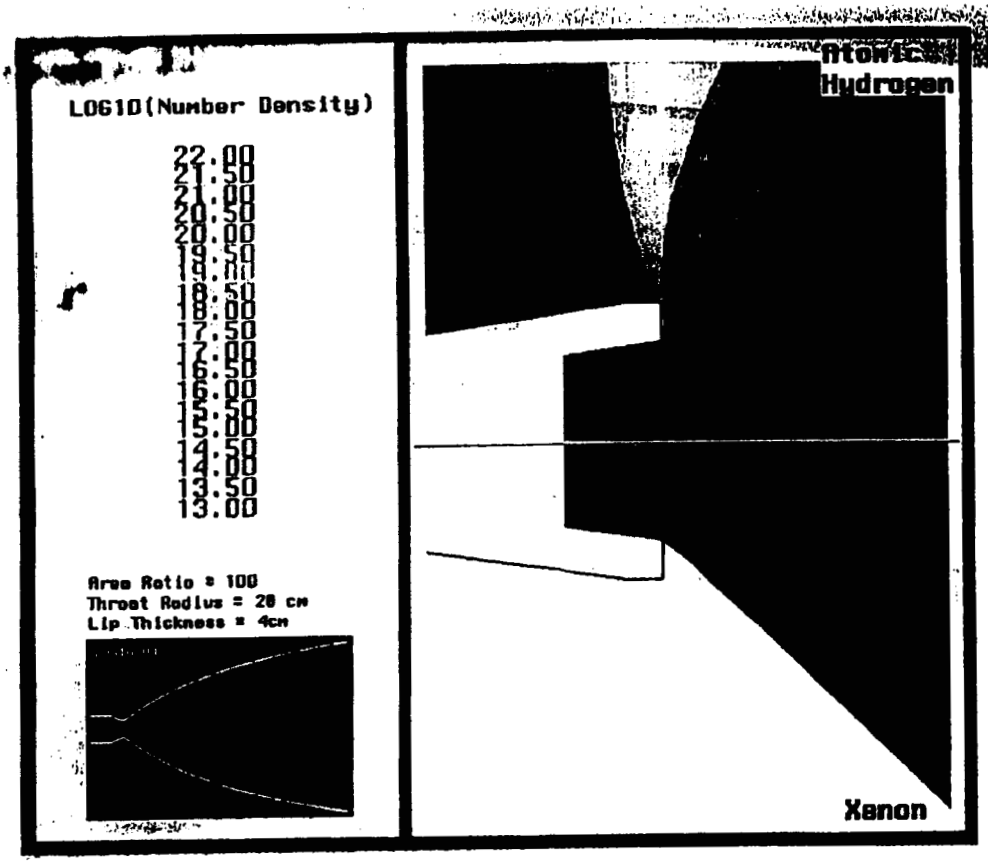

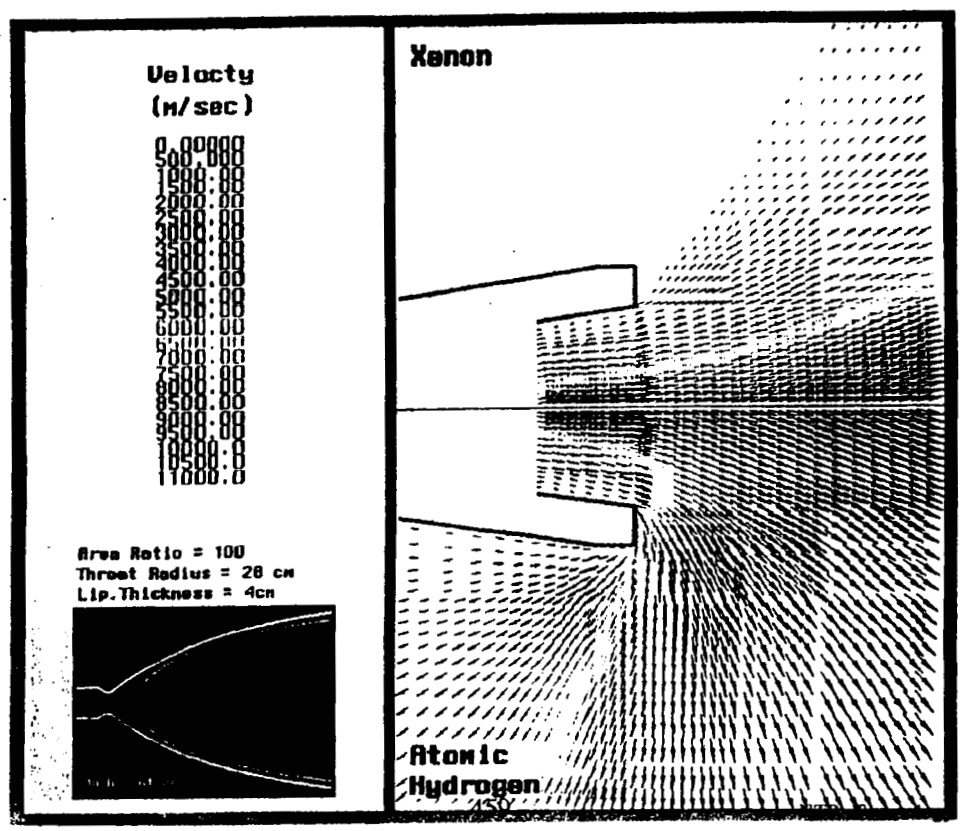

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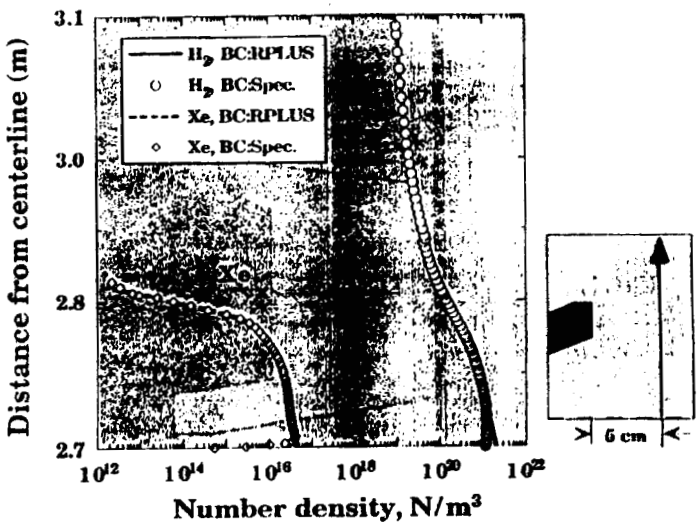

Fig.2 Density profile along the line parallel to exit plane

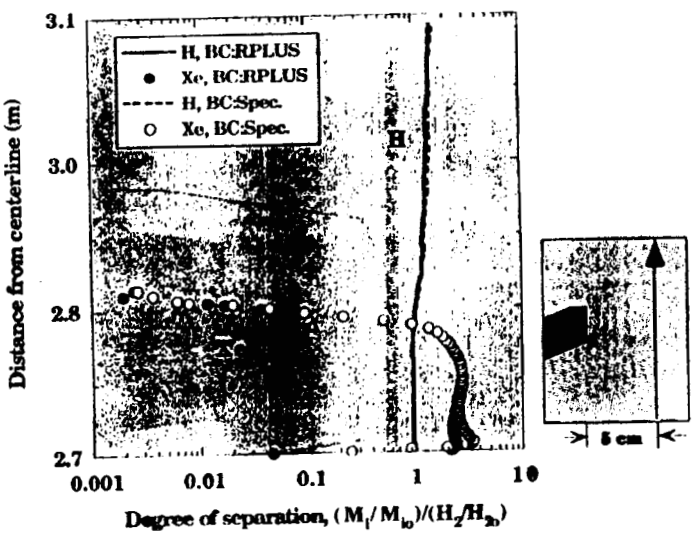

Fig.3 Degree of separation along the line parallel to exit plane