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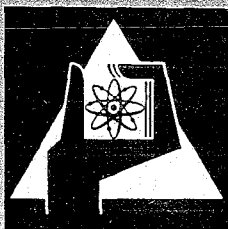
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Production of Fast Molecular Beams

Using Supersonic Plasma Jet

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## Production of Fast Molecular Beams Using Supersonic Plasma Jet

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**F**AST molecular beams are commonly generated by charge exchange of ionic beams. With this method, however, the attainable beam intensity is very low at kinetic energies around 5 eV because of space charge effects. In the present work<sup>1</sup> very high beam intensities were attained in the same energy region by skimming and collimating the core of a supersonic jet from an arc heated source. This method was used by Clausnitzer<sup>2</sup> for the generation of dissociated hydrogen beams. Although the same method was suggested by Knuth<sup>3</sup> as well as McGinn and Wachman<sup>4</sup> for the production of fast molecular beams, no experimental results appear to have been published.

The experiments were carried out in a molecular beam apparatus described earlier.<sup>5</sup> The beam production system is shown in Fig. 1. The gas, heated up by the arc, expands through the nozzle as a supersonic plasma beam, the core of which passes through the skimmer and the collimator as a molecular beam in the high vacuum chamber. The

use of an insulated and current free intermediate electrode has been found to be advantageous for attaining high beam energies. The electrodes and the skimmer were cooled with water. A Pitot tube combined with a diaphragm manometer was used for measuring the molecular beam intensity<sup>6</sup> and a time-of-flight setup for measuring the velocity distribution.<sup>7,8</sup>

The following data were obtained with argon. With increasing skimmer-nozzle distance  $d$  the intensity goes through a maximum at  $d=18$  mm. The intensity is independent of the arc source pressure  $p_0$  in the range 2–3.3 atm and decreases slightly with increasing current. The maximum intensity of  $10^{18}$  particles/cm<sup>2</sup>sec, obtained at a distance of 64 mm from the skimmer entrance, is higher than that in an argon molecular beam from a room temperature nozzle<sup>9</sup> by a factor approximately equal to the ratio of the beam velocities. On the other hand the intensity is about  $10^9 \times$  higher than that obtainable by charge exchange of ionic beams, for the same energy.<sup>10</sup> The Mach number is almost independent of  $p_0$  and  $d$  for  $d > 10$  mm, but decreases from 10 to 7 when the current is increased from 30 to 250 A. At the same time the kinetic energy increases from 1.5 to 5.7 eV.

With helium a molecular beam energy of 2 eV was obtained. At present the possibility of accelerating heavier seed particles<sup>7,11</sup> in helium beams is being investigated. It is expected that a kinetic energy in the region of 20 eV can be attained for argon particles seeded in the molecular beam.

Our thanks are due to Prof. E. W. Becker for suggesting this work and for his continuous support.

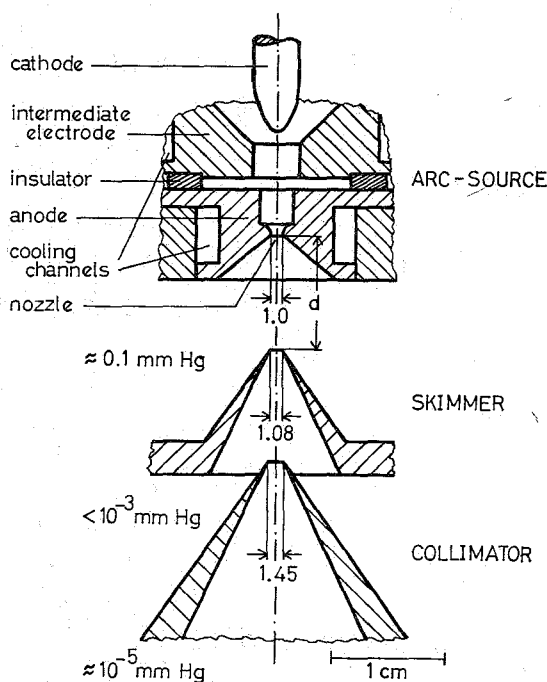


FIG. 1. The beam producing system. The collimator, skimmer, anode, and intermediate electrode are made of copper, the cathode of thoriated tungsten. (Dimensions are in millimeters.)

<sup>1</sup> Further details of the experiments will be published shortly.  
<sup>2</sup> G. Clausnitzer, *Helv. Phys. Acta, Suppl.* **6**, 35 (1961).  
<sup>3</sup> E. L. Knuth, *Conf. Mol. and Atomic Gas Beams and Related Problems*, May 1963, University of Virginia, Charlottesville, Virginia.  
<sup>4</sup> J. McGinn and H. Wachman, *Conf. Mol. and Atomic Gas Beams and Related Problems*, May 1963, University of Virginia, Charlottesville, Virginia.  
<sup>5</sup> E. W. Becker, R. Klingelhöfer, and P. Lohse, *Z. Naturforsch.* **17a**, 432 (1962).  
<sup>6</sup> E. W. Becker and K. Bier, *Z. Naturforsch.* **9a**, 975 (1954).  
<sup>7</sup> E. W. Becker and W. Henkes, *Z. Physik* **146**, 320 (1956).  
<sup>8</sup> O. Hagen and W. Henkes, *Z. Naturforsch.* **15a**, 851 (1960).  
<sup>9</sup> K. Bier and O. Hagen, *4th Int. Symp. Rarefied Gasdynamics*, July 1964, Toronto, Canada.  
<sup>10</sup> J. B. Anderson, R. P. Andres, and J. B. Fenn, *Advan. Atomic Mol. Phys.* **1**, 345 (1965), Fig. 7.  
<sup>11</sup> R. Klingelhöfer and P. Lohse, *Phys. Fluids* **7**, 379 (1964).