CC/NUMBER 35
AUGUST 27, 1990

This Week's Citation Classic®

Boyd R L F & Twiddy N D. Electron energy distributions in plasmas. I. *Proc. Roy. Soc. A* 250:53-69, 1959; and Electron energy distributions in plasmas. II. Hydrogen. *Proc. Roy. Soc. A* 259:145-58, 1960.
[Physics Department, University College London, England]

New ways to examine the nature and energy distribution of the ions and electrons in a glow discharge led first to the elucidation of the mechanism of the striated discharge and then to powerful methods for the direct examination of the ionosphere. [The *SCI*® indicates that the papers in this series have been cited in over 165 publications.]

Extracting Information Buried in Probe Characteristics

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February 8, 1990

After World War II, on joining the Mathematics Department of University College London (UCL), where H.S.W. Massey was intent on backing up his theoretical studies of the ionosphere with laboratory measurements of the ionic reaction rates, I was given an impossible PhD task. I was to determine the recombination coefficient of oxygen positive and negative ions from the equilibrium of a glow discharge in oxygen. The concentration of the negative ions was to be found from the ratio of the positive and negative saturation currents of a Langmuir probe characteristic; the energy distribution of the electrons, assumed Maxwellian, would enable the ionisation rate to be calculated; the primary loss process for ions was supposed to be recombination. In fact, none of these things held, and I found myself developing three techniques essential to the understanding of the plasma—a screened probe to separate the positive ion from the electron part of the characteristic, a mass spectrometer probe to identify the ions, and a means of determining the electron energy distribution. The papers cited above are about the last of these.

Two separate researches resulted—the study of electrical discharges and of plasmas in space. N.D. Twiddy developed and used the energy distribution technique to understand the mechanism of striated discharges first in hydrogen and then in the inert gases.[1] Later, having moved to Aberystwyth, he continued a very successful study of laboratory plasmas. J.B. Thompson and I used the method to measure the negative ion concentration in oxygen.[2] With another student, F.D.A. Boylett, I used related ideas to measure the energy distribution of the positive ions by operating directly on a sample beam extracted from the glow.[3] This work confirmed the interpretation of the striation mechanism that Twiddy and I had demonstrated.

While Twiddy and Thompson were engaged in this work, I was also involved with other colleagues in extending the methods to ionospheric studies using spacecraft—the direct approach to the field of study that had stimulated my first (hopeless) task in the attic of Foster Court. We used a screened spherical probe to find the energy distribution of the ionospheric ions and so to obtain their temperature and mass spectrum.[4] This is possible because satellites in the ionosphere move hypersonically so that the energy of arrival of the ions is proportional to their mass and the temperature may be obtained from the width of the mass spectrum line. The electron temperature, being Maxwellian, was found from the ratio of the first and second derivatives of the Langmuir characteristic of a plane probe.[5] I think it would be fair to say that the Mullard Space Science Laboratory of UCL grew out of the success we had with these techniques on *Ariel 1*.

1. Twiddy N D. Electron energy distributions in plasmas. III. The cathode regions in helium, neon and argon. *Proc. Roy. Soc. A* 262:379-94, 1961. (Cited 20 times.)
2. Boyd R L F & Thompson J B. The operation of Langmuir probes in electro-negative plasmas. *Proc. Roy. Soc. A* 252:102-19, 1959. (Cited 20 times.)
3. Boyd R L F & Boylett F D A. Ion and electron energy distribution in the hydrogen discharge. *Proc. Roy. Soc. A* 296:233-42, 1967. (Cited 10 times.)
4. Bowen P J, Boyd R L F, Raitt W J & Willmore A P. Ion composition of the upper F-region. *Proc. Roy. Soc. A* 281:504-14, 1964. (Cited 35 times.)
5. Bowen P J, Boyd R L F, Henderson C L & Willmore A P. Measurement of electron temperature and concentration from a spacecraft. *Proc. Roy. Soc. A* 281:514-25, 1964. (Cited 30 times.)

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