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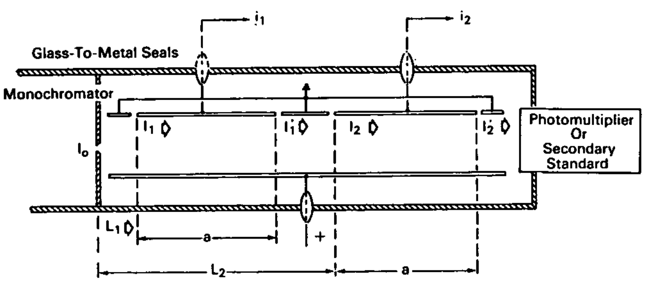
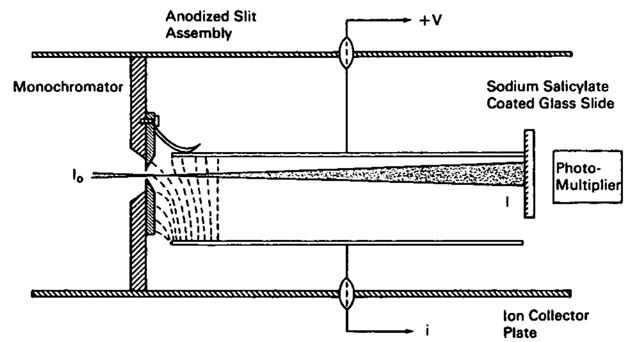
NASA TECH BRIEF

Ion Chambers Simplify Absolute Intensity Measurements in the Vacuum Ultraviolet



THE DOUBLE ION CHAMBER



THE SINGLE ION CHAMBER

The problem:

Techniques to measure the absolute intensity of radiation in the visible and infrared region of the spectrum are well established and involve the calibration of the response of a thermopile or some other detector to radiation emitted from a National Bureau of Standards lamp. In the extreme ultraviolet region of the spectrum, however, the flux density emitted is far weaker than in the visible, making it more difficult to use a thermopile to achieve accurate measurements.

A very important parameter in the study of planetary atmospheres and in upper atmospheric research is the photoionization cross section. To obtain this parameter, it is essential to know the absolute intensity of the ionizing radiation. The importance of intensity measurements far exceeds that of measuring only photoionization cross sections. For example, the present generation of solar extreme ultraviolet measurements are made with either uncalibrated or poorly calibrated detectors, mainly because of the extreme difficulties encountered in this spectral region.

The solution:

A technique utilizing a single or double ion chamber to measure absolute intensities of radiation below 1000 Å. The ion chambers use the rare gases as the ion carrier and since each photon absorbed by the gas creates one ion pair then a measure of these ion pairs will be a measure of the number of incident photons.

How it's done:

The one direct means to determine the absolute intensity of radiation in the vacuum ultraviolet from a given source is based on the photoionization of the rare gases; however this limits its direct usefulness to radiation below 1022 Å (the ionization potential of xenon). This method is based on the assumption that the photoionization yield of the rare gases is unity. However, if the assumption is accepted, the method resolves itself to the determination of an electric current (ions/sec), which is then related to the absolute number of photons/sec absorbed by the gas. The lifetime of these radiationless transitions into the ionization continuum is of the order of 10^{-15} sec and

(continued overleaf)

therefore, they have an extremely high probability of producing an ion/photon absorbed in the autoionization region.

An experimental approach to the measurement of the photoionization yield for the rare gases is to measure their yields relative to one gas, say xenon. If these yields all turn out to be constant with respect to xenon, especially in regions of autoionization, then this is excellent evidence that the constant photoionization yield must be unity. A further check with a calibrated thermopile may lend confidence to this assumption.

Two ion chambers, a double and a single, were used to measure the photoionization yields of gases. The major advantage of the double ion chamber lies in the fact that all the variables, i.e., the two ion currents and the detector output, can be measured simultaneously, thereby eliminating any discrepancies due to light source fluctuations. The major advantage of the single ion chamber is that no measurement of an absorption coefficient is made which must obey Beer's law, which states that "the amount of light absorbed is proportional to the number of absorbing molecules through which the light passes."

Notes:

1. The simplicity and accuracy of this method of absolute intensity measurements suggests that it could become a standard for the calibration of thermocouples, thermopiles, bolometers, and other radiation detectors.
2. Further information concerning this innovation is given in "Planetary Aeronomy XI: Absolute Intensity Measurements in the Vacuum Ultraviolet," by J. A. R. Samson, in NASA contractor report, NASA CR-7, September 1963. Inquiries may also directed to:

   Technology Utilization Officer
   Electronics Research Center
   575 Technology Square
   Cambridge, Massachusetts 02139
   Reference: B66-10439

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: J. A. R. Sampson
of Geophysics Corporation of America
under contract to
Electronics Research Center
(ERC-10)