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A New Scaling Law of Resonance in Total Scattering Cross Section in Gases

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Electrical discharges in gases continue to be an active area of research because of industrial applications such as power systems, environmental clean up, laser technology, semiconductor fabrication etc. A fundamental knowledge of electron-gas neutral interaction is indispensable and, the total scattering cross section is one of the quantities that have been measured extensively. The energy dependence of the total cross sections shows peaks or resonance processes that are operative in the collision process. These peaks and the energies at which they occur are shown to satisfy a broad relationship involving the polarizability and the dipole moment of the target particle. Data on 62 target particles belonging to the following species are analyzed. (Eq 1) Rare gas atoms (Eq 2) Di-atomic molecules with combinations of polar, non-polar, attaching, and non-attaching properties Poly-atomic molecules with combinations of polar, non-polar, attaching, and non-attaching properties. Methods of improving the newly identified scaling law and possible application have been identified. 1 INTRODUCTION: Data on electron-neutral interactions are one of the most fundamental in the study of gaseous electronics and an immense literature, both experimental and theoretical, has become available since about the year 1920. [1-5]. In view of the central role which these data play in all facets of gas discharges and plasma science, it is felt that a critical review of available data is timely, mainly for the community of high voltage engineers and industries connected with plasma science in general. The electron-neutral interaction, often referred to as scattering in the scientific literature, is quantified by using the quantity called the total scattering cross section (Q_T, m^2). In the literature on cross section, total cross section and total scattering cross section are terms used synonymously and we follow the same practice. A definition may be found in reference [1]. This paper concerns scaling of total cross section of gases at resonance energy and the electron energy at which resonance occurs. The meaning of resonance is briefly explained in the following section. Here, we use the term scaling to relate the two quantities mentioned, namely, the resonance energy and the total cross section at that energy. Consistent with the definition of scaling, if the law proposed holds, one of the two quantities mentioned above may be calculated if the other is known. Such a method is very useful in gas discharge modeling and calculation of breakdown voltages, as more fully explained in the later section of the paper. 2 DESCRIPTION OF RESONANCE: A brief description of resonance phenomena in several types of target particles, viz., atomic, poly atomic, polar, non-polar phenomena are presented. 3 PREVIOUS SCALING LAWS: A common representation of a given characteristic with as few adjustable parameters as possible is generally known as the scaling law. The Paschen curve for breakdown voltage is such a familiar scaling law. With reference to cross sections several attempts have been made to obtain a scaling law, with varying degree of success. If the cross section-energy curve is qualitatively similar without having sharp peaks and oscillations, moderately successful scaling laws may be devised. For example, the ionization cross section- energy curves for most gases follow a general pattern. Several published scaling laws are discussed. 4 A NEW SCALING LAW AND DISCUSSION: In this work the author has compiled the resonance details for more than