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Elementary Charge and Electron: One Entity Two Identities

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Our knowledge of electricity is based on two nearly parallel concepts – charge and electron. The charge concept is symmetrical: nature has equal numbers of positive and negative charges playing equivalent roles in atoms. The electron concept has two asymmetries. One, the observable universe has more positive than negative electrons. Two, atoms contain negative- but no positive electrons. Here I propose that charge is static electron and electron is moving charge. That is, resting (electrostatic) and moving (electrodynamic) behaviours exclusively make charge and electron different. The proposal reveals previously unnoticed symmetries in the electron concept and has experimental backing. Faraday, Stoney and Millikan observed charges in static conditions – electrolytes, oil drops, doorknobs etc. In contrast, Thomson and Anderson observed electrons at high speeds in cathode tubes and cloud chambers. Beta decays were initially interpreted to mean existence of electrons in atomic nuclei. Equating 'charge' to 'static electron' reinstates and validates the interpretation.

Key words: Charge, electricity, electron, electrodynamics, electrostatics, elementary charge

George Thomson observed that electron "can never be separated" from its charge[1]. This fact is unique to the electron. Other charged particles do lose their charge. Proton, for example, loses its positive charge in β^+ decay[2]. In contrast, electron does not decay to anything simpler[3]. Thus, nature has no chargeless (electrically neutral) electron. But does nature contain charge without electron?

Charge, or elementary charge, is currently conceptualized as an independent entity that electron carries but cannot lose; and which some other particles carry but can lose. Proton's positive charge seems like an obvious case of charge existing without electron. Contrary to expectation, however, proton does not decay to positive charge. Rather, it decays to positive electron – which is said to 'carry' the positive charge. With no exception, a lost or a gained charge – whether positive or negative – is traceable in an electron. Consequently, pure charge – free from electron – has never been isolated[4]. Ultimately, therefore, neither chargeless electron nor electronless charge has ever been observed. Put differently, neither charge nor electron exists independent of the other. This implies that charge and electron are either permanently cojoined entities or are the same entity in different guises.

In his 1874 treatise George Stoney interpreted Faraday's laws of electrolysis to mean that "positive as well as negative" electricity, like matter, ultimately comprises indivisible particles[5]. He suggested the name "electron" for "atom of electricity"[6]. To Stoney and his contemporaries, positive and negative electricity meant positive and negative elementary charges as detected in electrochemical processes. Millikan's experiment proved "very directly"[7] that a quantity of charge is an integral multiple of elementary charge. That is, Stoney's charges constitute a 'real quantity' akin to that of ordinary mass particles.

However, the fundamental nature of Stoney's 'charge' was, and still is, incoherent[8, 9] – with no clear formulas linking it to familiar parameters[10]. In 1897 J.J. Thomson discovered a better-defined particle that was finally named electron[11]. Thomson's electron is more intelligible than Stoney's charge, which it tended to eclipse. Like an ordinary particle, electron has rest mass and carries momentum. As a piece of matter, electron occupies space. For this reason, a quantity of electrons is more comprehensible than a quantity of charges. Further, it was shown that electron is a concrete subatomic particle[12]; a universal building block of atoms; and so stable that it is considered 'virtually immortal'[13].

Thus, electron compares well with an ordinary particle of infinitesimal size. Unlike an ordinary particle, however, electron exhibits electric behaviours. By the time Thomson made his discovery scientists already knew that charge exhibits either positive or negative electric behaviours. But Thomson's electron was invariably electrically negative, making it different from Stoney's charge. This particular distinction disappeared when Dirac and Anderson discovered positron, showing that electron, like charge, is either positive or negative. Based on current interpretations, the difference between charge and electron is subtle but significant.

In charge concept: 1) Electricity comprises individual elementary charges. However, the physical meaning of a 'charge' is enigmatic[14]. 2) Charges exist in positive and negative types but their physical distinction is unknown. 3) Nature has equal numbers of positive and negative charges. Hence, charge is conserved. 4) An atom has equal numbers of positive and negative charges, resulting in overall electric neutrality.

In electron concept: 1) Electron and charge are different entities. Charge, rather than electron, is responsible for electric phenomena. But the physical meaning of charge is unknown. 2) Electron carries charge; opposite electrons carry opposite charges[15]. In addition to electron, some other particles carry charge. 3) Positive and negative charges in observable universe balance out but negative electrons outnumber positive electrons [16]. 4) Negative electron is a fundamental building block of atoms but positive electron is not.

The charge concept is symmetrical: nature has equal numbers of positive and negative charges that play equivalent roles in atoms. The electron concept is asymmetrical: there are more negative- than positive electrons while positive electrons are altogether absent in atoms. The asymmetries are either natural or result from misinterpreted facts. Based on intuition and past discoveries, symmetry is anticipatable at such rudimentary level of material organisation. According to Gross, symmetry is the guiding principle in the search for unification[17].

The electron concept would become symmetrical if there is a natural way to equate charge to electron. Replacing 'charge' with 'electron' in the atom would mean that the atom has equal number of negative orbital- and positive nucleus electrons. The positive-negative charge symmetry would translate to positive-negative electron symmetry or equal numbers of positrons and negative electrons in the observable universe. This dream is achieved by proposing that charge is static electron and electron is moving charge.

The proposal may face immediate objection. Since an atom has negative electrons in the orbits, and given that subatomic distances are very short, presence of positive electrons in the nucleus would result in electron pair annihilation and thus render the atom unstable. The assumption behind this objection is that low speed (static) and high speed (dynamic) electrons obey the same laws. However, it is known that charges obey the laws of electrostatics, which allow opposite charges to coexist, but electrons obey the laws of electrodynamics, which allow opposite electrons to annihilate. That is, resting (electrostatic) and moving (electrodynamic) behaviours, exclusively, make charge and electron appear like different entities.

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The proposal has experimental and theoretical backing. Faraday, Stoney and Millikan observed charges in static conditions – electrolytes, oil drops, glass rods, jars, doorknobs etc. In contrast, Thomson and Anderson observed electrons at high speeds in vacuum cathode tubes and cosmic rays. Dirac treated electron as a light, fast moving particle and thus incorporation special relativity in his equations.

Based on the new proposal, negative electrons dominate the observable universe only because observations are limited to environmental (moving) electrons. The fact that static positive electrons occupy the atomic nuclei and are shielded by negative orbital electrons explains their rarity in extra-atomic environments. Universally, however, numbers of positive and negative electrons – observable at low speeds as charges and at high speeds as 'electrons' – are perfectly equal. Therefore, conservation of electric charge encompasses conservation of electron.

Anderson and Curie established that positrons originate from atomic nuclei[18, 19]. Equally, negative electrons arise from atomic nuclei in β^- decay. Prior to 1934, β decays were interpreted to mean that electrons exist in atomic nuclei[20, 21]. The view was dropped after it was discovered that opposite electrons coexisting at such short distances should annihilate[22]. The prevailing view is that β particles do not exist in atoms but are produced as secondary emissions[23].

Lawncizak and Åsbrink examined "possibility and probability of the four main theories" that attempt to explain β^+ decay: pion decay, muon decay, magnetic field bending and pair production. They concluded that "the probability of discovering a positron [from] any of the theorized origins is extremely low and for some theories, even impossible." The problem is solved in unforced manner when charge is recognized as static electron. Evidently, β decay coverts charge to electron. In equivalent electrochemical reactions, negative charge absolves extra energy and converts to negative electron. In nuclear reactions, however, the emitted electron is invariably accompanied by a neutrino.

Based on sound theoretical evidence and backed by experimental proofs, it is concluded that charge and electron describe an 'atom of electricity' in completely different states of motion. The implication is that observable universe, including atoms, contain equal numbers of positive and negative 'atoms of electricity'. The physical nature of the 'atom of electricity', and the physical distinction between positive and negative 'atoms', remain unsolved problems.

Competing financial interests

The author declares that he has no competing financial interests.

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