PROPOSED EXPERIMENT TO EXPLORE THE TIME-DEPENDENCE OF THE ONSET OF THE PAULI PRINCIPLE (PP)

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Note: This lecture is distributed in the hope of finding an experimentalist with access to a linear accelerator who is interested i performing the proposed experiment. Although the highly probable outcome will favor a zero onset time of PP, the possibility of of a radical result – a non-zero onset time -- may be attractive to an experimentalist of the proper temperament.

Motivations for the proposed experiment:

1. PP is so fundamental that the discovery of even rare exceptions to it, not attributable to experimental error, would be physically significant.
2. Previous experimental tests of PP did not explicitly examine electron ensembles at variable short times after their formation.
3. There exists a model (Corinaldesi's) that exhibits invalidity of PP for new ensembles and its asymptotic validity for long times.
4. The proposed experiment does not test this specific model but rather the phenomenological proposition that exceptions to PP occur in sufficiently new ensembles.
5. An assumption of Pauli's spin-statistics theorem, exact validity of local Lorentz invariance, may fail in quantized general relativity.

1. Prepare a very large number of electron ensembles with nearly definite time intervals T between time of formation and time of monitoring for violation of PP.
2. Achieve time intervals $T \leq \tau$, where τ is the characteristic time for the onset of P
3. Ensure that the method of recognizing a violation of PP is reliable.

Design

Begin with a well collimated beam of singly ionized Ne^{+} flowing at velocity v (for specificity c/100) in the tube of a linear accelerator. A mobile electron gun located on a line on the inner surface of the accelerator parallel to its axis X produces a well directed flux of electrons intersecting the Ne^{+} beam in the small interval $x \pm \delta$, where δ is a fixed small length determined by the features of the electron gun and the Uncertainty Principle. The value x=0 labels the furthest location downstream that is accessible given the mounting of the electron gun. The component of velocity of the electrons along the X-axis is chosen equal to the velocity of the Ne^+, and their transverse velocity is chosen to maximize the probability of capture of an electron by an ion. The class E_X of ensembles consists of the ensembles of electrons (each consisting of ten electrons) of those Ne atoms formed by the capture of an e by an ion Ne^+ in the interval $x \pm \delta$.

The rate of formation of members of the class E_X is monitored by a gamma-detector Δ'_0 sensitive to gammas of the energy range characteristic of the capture of electrons from the gun by neon ions, presumably almost entirely in the 2p shell of the ion. Δ'_0 is located on the inner surface of the accelerator with δ as the X-component of the position of the most upstream point of the detector's aperture , which is oriented so as to avoid the beam of electrons from the gun and of course the gun itself. Another gamma detector Δ_0 has the same X-component of position, but is sensitive to an anomalous gamma signaling either the capture of a beam electron into the 1s shell of the ion or the transition of an atomic electron from 2p to 1s; either is possible even if the 1s shell is previously doubly occupied provided that the electron is not governed by PP.

Downstream from Δ'_0 and Δ_0 is an array of detectors Δ_k (k = 1,...,n) with the same sensitivity as Δ_0 and positions to be discussed. The class of ensembles E_x consists of individual ensembles E_{xk} which, for a given x and k consists of the electrons of those Ne atoms that were constituted from Ne^+ at position x and monitored by the detector Δ_k, so that its age is expressed by

$$T = v[-x + kD \pm d/2], \qquad (1)$$

where v is the flow velocity of the Ne^+ ions, D is the distance between centers of successive detectors, k labels the detector, and d is the diameter of the aperture of a detector (assumed to be all the same). Note that an individual Ne atom formed when a Ne^+ ion captures an electron at x successively belongs to ensembles E_{xi} as it travels down the axis of the linear accelerator, allowing an anomalous gamma to be detected at any of the detectors Δ_k.

The appropriate number of gamma detectors and their spacing depends depends on the time required for the onset of the regime in which PP holds. It would be economical to install initially only detectors Δ'_0 and Δ_0 and to install further detectors Δ_k if an experiment using only the first two detectors yields very surprising results. If Eq. (1) is used with k=0, v= 3 x 10^{-8} cm/sec for specificity, and x varied in conveniently small steps, three types of results could be found:

1. No anomalous gammas are observed no matter how close to 0, as permitted by the controls of the electron gun, x is taken. This result would imply either that the time τ of onset of PP is 0, and the experiment has ended in confirmation of PP regardless of the age of the ensemble of electrons, or else that τ is extremely short, specifically for v= 3 x 10^8 cm/sec and 10^{-6} cm as the minimum steps of x the onset time τ would have to be less than 3 x 10^{-15} sec,

and it would not be surprising that violations of PP have
not been previously noticed. If one still wanted to search for a finite onset time, one would need a higher value of v, even closer to the velocity of light, or greater refinements of focusing the electron gun. In either case further detectors with k = 1,…,n are not needed.

2. Anomalous gammas are seen by detector Δ_0 at rates which decrease as x is made further and further to the left of 0. Then by fitting an exponential curve one could infer the mean value of the onset time τ. The experiment would yield the radical result that PP is violated for new ensembles and it would be informative about the time required for the onset of PP.

3. Anomalous gammas are seen by detector Δ_0 at roughly the same rate for all choices of x compatible with the controls of the electron gun. Then it would be reasonable to infer that PP is violated for sufficiently new ensembles, but the onset time τ could not be determined without inserting and using a sufficient number of the additional detectors Δ_k. Since the onset time would be

large by atomic standards, this result is highly implausible in view of the extraordinary success of PP since 1925.

Theoretical speculation:

In view of the great success of PP in explaining physical phenomena it is antecedently improbable that there is a non-zero onset time before an ensemble of electrons is governed by PP. But a reason for speculating a finite onset time is suggested by Pauli's 1940 paper "The connection between spin and statistics," which rests upon several assumptions, including the local validity of special relativity – an assumption which is preserved in general relativity theory. If, however, there is a sufficient local modification of general relativity for quantum mechanical reasons this assumption would break down, opening the possibility of the finiteness of the onset time of PP. This consideration not only provides a motivation for carrying out the experiment proposed here, but also shows that an unexpected result would provide hitherto inaccessible insight into space-time structure.

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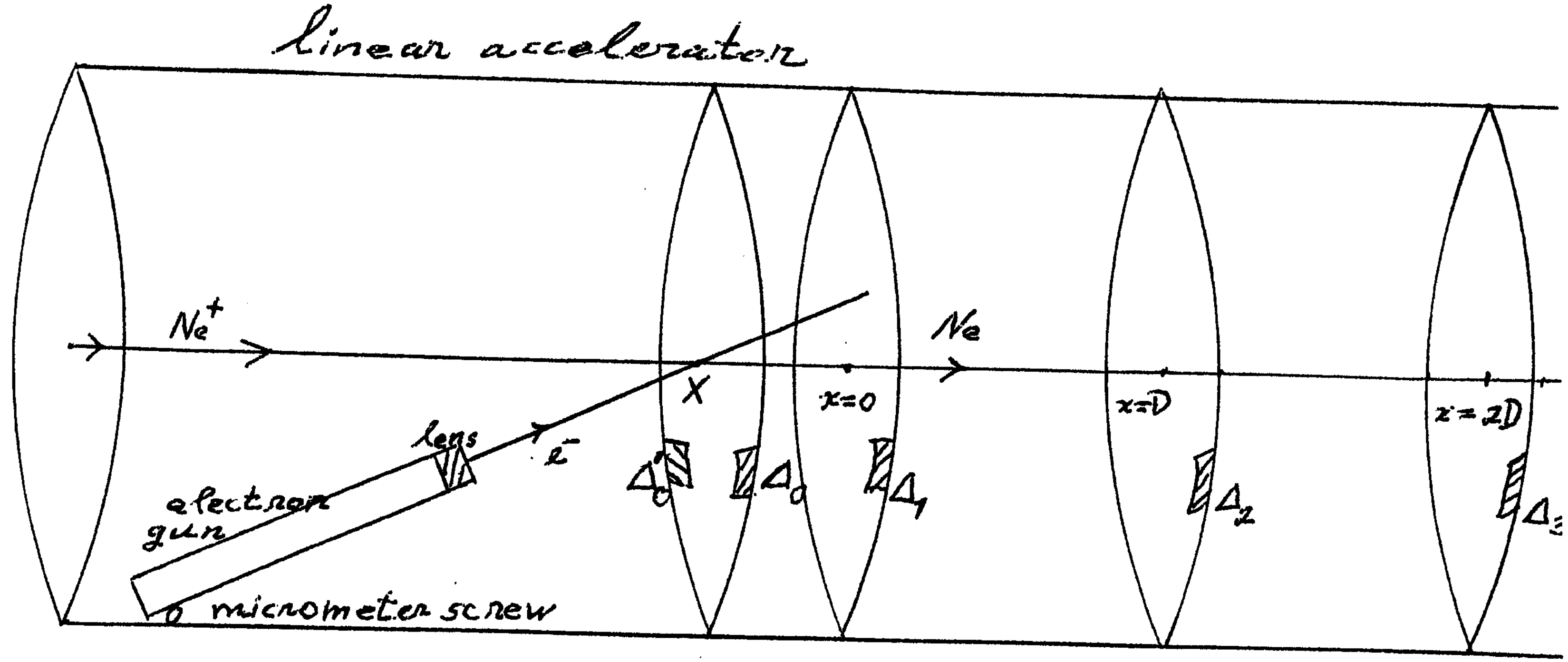

Fig. 1 Micrometer screw moves X in steps of 10^{-4} cm.
Lens moves X in steps of 10^{-6} cm.
Detectors Δ_0 and Δ_0' at X, both movable.
Detectors $\Delta_1, \cdots, \Delta_{10}$ fixed, separated by 80 cm.
Diameter of each detector: 2.5 cm.
Diagram not drawn to scale.