Letters to the Editor

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Combination of Betatron and Synchrotron for Electron Acceleration

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November 13, 1945

IN a recent letter E. M. McMillan[1] discusses a possible design for a 300-Mev electron accelerator known as a synchrotron. If electrons are injected into the synchrotron with 300-kev energy, the radius of their orbit varies from 78 cm to 100 cm as their velocity gradually approaches that of light. Thus the magnetic field must cover a ring of width greater than 22 cm in order to shape the field properly.

It should be possible to reduce the width of this magnetic flux ring by using the betatron principle of acceleration until the electron energy has reached 2 or 3 Mev. Electrons could be injected into a betatron[2,3] orbit by a small gun pulsed to 50 or 100 kv. They would be further accelerated on this orbit of radius slightly less than 100 cm by increasing the flux in a relatively small central magnetic core, designed to saturate when the electron energy increased to some appropriate value over 2 Mev. Before the core saturated, R.F. accelerating voltage would be applied with proper timing to the gap in the toroidal vacuum tube. Thereafter the energy gain of the electrons would come almost entirely from passage across the accelerating gap. As the equilibrium energy of the particles increased, the proper energy change per cycle would be controlled by the phase stability which characterizes the synchrotron.

The combination of betatron acceleration at low energies with synchrotron acceleration at high energies, where radiative losses become serious, should allow a saving of considerable magnet weight in machines designed for the billion-volt range. To test the design, a 70 Mev accelerator of this type is being constructed at the General Electric Research Laboratory at Schenectady, New York.

It is understood that Powell and Bohm at Berkeley have noticed independently the desirable features of this form of electron injection and that it will probably be employed in the 300 Mev machine proposed in McMillan's letter.

[1] E. M. McMillan, Phys. Rev. **68**, 143 (1945) (communicated to the author before publication).
[2] D. W. Kerst, Rev. Sci. Inst. **13**, 387 (1942).
[3] W. F. Westendorp and E. E. Charlton, J. App. Phys. **16**, 581 (1945).

A Theory of the Low Mass Neutral Mesotron

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February 1, 1946

IT has been shown by F. Bopp[1] and B. Podolsky,[2] if the Lagrangian of the electromagnetic field depends upon both the field strengths and their first derivatives, (a) that the electrostatic self-energy, which diverges for a Maxwellian field, is finite; (b) that the field potentials, φ_α, satisfy a fourth-order equation of the form

$$(1-a^2\Box)\Box\varphi_\alpha \tag{1}$$

with the static solution

$$\varphi=(\epsilon/r)(1-e^{-r/a}); \tag{2}$$

and (c) that the field is a superposition of fields of quanta of rest masses 0 and $\hbar/ac$.

The purpose of the present note is to point out a possible relationship between this new field theory and the low mass neutral mesotrons reported by G. Groetzinger, P. G. Kruger, and L. Smith.[3]

Several values for the constant a have already been proposed. Bopp has given $a=r_0/2$, which leads to 2(137) m_0 for the mass of the heavy particle, where r_0 is the classical electron radius and m_0, the electron mass. Landé,[4] on the other hand, proposed the value $\frac{2}{3}r_0$ for a, giving $\frac{3}{2}(137)m_0$ for the neutral mesotron mass. However, it occurred to the author[5] some time ago that there is still another possible value for a. If the electron-proton interaction potential in the hydrogen atom is assumed to be given by Eq. (2), the perturbation energy of the $2S$-level due to the exponential term is found to be

$$\Delta E\sim a^2\epsilon^2/2a_0^2$$

or, in wave numbers,

$$\Delta\nu(2S)\sim a^2\epsilon^2/2a_0^3ch=(\alpha^6a^2/2r_0^2)(m_0\,c/h),$$

where ϵ is the electronic charge, a_0, the Bohr radius of the hydrogen atom, and $\Delta\nu$ the wave number shift. Using Pasternack's value of 0.03 cm^{-1} for the $2S$-level displacement, we find that $a\sim 10r_0$, giving

$$m=\hbar/ac\sim 14m_0.$$

This agrees remarkably well with the value, $16m_0$, quoted by G. Groetzinger and L. Smith.[6]

The use of the potential given in Eq. (2) for the electron-proton interaction is not free from objections, for, according to the well-known argument of Pasternack,[7] the electron-proton force must become repulsive for small distances. In the result published recently by A. Pais,[8] this difficulty is avoided by using

$$\epsilon\varphi=-(\epsilon^2/r)(1-2e^{-r/a})$$

from which he obtains $2.5r_0$ for a. This value, however, gives $55m_0$ for the neutral mesotron mass.

[1] F. Bopp, Ann. d. Physik **38**, 345 (1940).
[2] B. Podolsky, Phys. Rev. **62**, 68 (1942).
[3] G. Groetzinger, P. G. Kruger, and L. Smith, Phys. Rev. **67**, 52 (1945).
[4] A. Landé, Phys. Rev. **60**, 121 (1941).
[5] C. Kikuchi, Thesis, University of Washington (1944).
[6] G. Groetzinger and L. Smith, Phys. Rev. **68**, 55 (1945).
[7] S. Pasternack, Phys. Rev. **54**, 1113 (1938).
[8] A. Pais, Phys. Rev. **68**, 227 (1945).