Table II. ΔE (in MeV) for P states ($\hbar\omega = 8.5$ MeV).

	$^3P_0$		$^3P_1$		$^3P_2$	
	Present theory	Elliott	Present theory	Elliott	Present theory	Elliott
0	−0.92	−1.36	0.67	0.88	−0.44	−0.49
1	−0.93	−1.25	1.03	1.16	−0.88	−0.89
2	−0.70	−0.82	1.31	1.45	−1.20	−1.17

his matrix method, for tensor coupling. The present method agrees with reaction-matrix methods about as well as they agree with each other. To correct for the omission of Pauli and binding effects, knowledge of the wave function, and therefore, of the two-nucleon interaction, would be necessary. It seems likely that the present method is accurate in the treatment of the tensor force, which has caused some trouble in reaction-matrix calculations.

Lastly, we compare our calculation of ΔE_{nlsj} for the states $^3P_{0,1,2}$ with those of Elliott, Mavromatis, and Sanderson (Table II of Ref. 5), both for $\hbar\omega = 8.5$ MeV, in Table II. The results are qualitatively similar, which suggests that there may be a weak pseudopotential, which satisfies the requirements of the theory of Elliott, Mavromatis, and Sanderson, and which approximately gives the low-energy P phase shifts in the Born approximation.

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[1]K. A. Brueckner, C. A. Levinson, and H. M. Mahmoud, Phys. Rev. 95, 217 (1954).

[2]W. B. Riesenfeld and K. M. Watson, Phys. Rev. 104, 492 (1956); N. Fukuda and R. Newton, Phys. Rev. 103, 1558 (1956).

[3]E.g., G. E. Brown, Unified Theory of Nuclear Models and Forces (North-Holland Publishing Company, Amsterdam, The Netherlands, 1967), Chap. XI.

[4]A. Kallio, Phys. Letters 18, 51 (1965).

[5]J. P. Elliott, H. A. Mavromatis, and E. A. Sanderson, Phys. Letters 24B, 358 (1967).

[6]T. Hamada and I. D. Johnston, Nucl. Phys. 34, 382 (1962).

[7]W. K. Niblack and B. P. Nigam, Phys. Rev. 156, 1191 (1967).

[8]Handbook of Mathematical Functions, edited by M. Abramowitz and I. A. Stegun, National Bureau of Standards Applied Mathematics Series, No. 55 (U. S. Government Printing Office, Washington, D. C., 1964).

[9]H. McManus and D. Grillot, private communication.

[10]Y. E. Kim, Phys. Letters 19, 583 (1965).

[11]M. H. Hull, Jr., and C. Shakin, Phys. Letters 19, 506 (1966).

[12]R. L. Becker and A. D. MacKellar, Phys. Letters 21, 201 (1966).

[13]T. T. S. Kuo and G. E. Brown, Nucl. Phys. 85, 40 (1966).

VARIABILITY OF ELEMENTARY CHARGE AND QUASISTELLAR OBJECTS

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In my recent paper,[1] I made a suggestion that Dirac's numerical relation

$$\frac{e^2}{\gamma M^2} = 1.24\times 10^{36} = t_{\mathrm{pres.}}, \tag{1}$$

where e is the elementary charge, γ the gravitational constant, M the mass of a nucleon, and where $t_{\mathrm{pres.}}$ is the present age of the universe expressed in elementary time units λ/c, may be interpreted by the assumption that, while γ remains constant, e^2 increases proportionally to t. I have suggested that this possibility may be tested by observing the value of the fine structure constant $\alpha = 2\pi e^2/hc$ in the distant galaxies. When making this suggestion, I was unaware that the test had already been made by Bahcall, Sargent, and Schmidt in their studies of the absorption spectrum of 3C-191.[2] At the end of that paper they write the following:

"We find that: $\alpha(z=1.95)/\alpha(z=0) = 0.94$, 0.97, and 1.01, respectively, for the Si II lines near $\lambda 1260$ and $\lambda 1527$ and the Si IV lines near $\lambda 1394$. We conclude that $\alpha(z=1.95)/\alpha(z=0) = 0.98 \pm 0.05$."

This indicates that although all lines of the spectrum are lengthened by a factor 2.945 ± 0.001, the separation between the fine-structure components of three doublets remains constant within 5%. The interpretation of this result is, however, somewhat uncertain due to the fact that there is still no general agreement concerning the nature of the celestial object in question, and, in particular, opinions are divided between the possibility of their cosmological or local interpretation.

I want to suggest here that the absorption spectra of the quasistellar objects (QSO) originates neither in their "atmospheres" nor in the intergalactic space, but rather in the individual galaxies through which their light passes on the way to us. In fact, if one assumes that QSO are located exclusively at very large (cosmological) distances from us, one can easily show that the probability of their occultation by the galaxies located somewhere between them and ourselves is very high. If one assumes that the distances between the neighboring galaxies are about a hundred times larger than their diameters, and that these distances are of the order of a few million light years, one finds that the "free path" of the light ray coming from QSO is $(10^2)^2\times 10^6 \cong 10^{10}$ light years, i.e., comparable with the observable part of the universe. The expansion of the universe will put the larger weight on the absorption in more distant galaxies.

This interpretation would explain why the absorption spectra of QSO are strikingly similar to the space absorption within our Milky Way. It also may explain their peculiar variability which, in this case, will not speak any more for the intrinsic variability at the source than the observed twinkling of stars speaks for their intrinsic variability. However, the problem of variability of elementary charge still remains open pending the definite solution of the nature of QSO and the study of pleochroic halos in old rocks which may reveal the changes of the energies and the decay constants of the natural radioactive elements.[3,4]

In view of these new arguments, the problem of variability of the universal constants can be reformulated in the following way. One assumes as the "natural" system of units the velocity of light c, the quantum constant h, and the elementary length $\lambda(\cong 10^{-13}$ cm) which presumably do not change with universal time. This leads to the following "true secondary constants":

(1) The mass of heavy particles

$$M \cong h/\lambda c \cong 10^{-24}\ \mathrm{g}. \tag{2}$$

(2) The range of nuclear forces (strong interactions)

$$\gamma_0 \cong \lambda \cong 10^{-13}\ \mathrm{cm}. \tag{3}$$

(3) The strength (depth of the potential well) of nuclear forces

$$U_0 \cong hc/\lambda \cong 10^{-4}\ \mathrm{erg} \cong 100\ \mathrm{MeV}. \tag{4}$$

(4) Fermi's constant of the weak interaction

$$g \cong ch\lambda^2 \cong 5\times 10^{-49}\ \mathrm{erg\ cm}^3. \tag{5}$$

For purely electromagnetic quantities, which may be time-dependent, we have the elementary charge

$$e \sim \sqrt{t}\quad \text{(possibly)} \tag{6}$$

and the electron's mass

$$m \sim t\quad \text{(possibly)}. \tag{7}$$

The latter possible assumption is made to keep the "classical" radius of the electron e^2/mc^2 equal to the (constant) elementary length λ.

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[1]G. Gamow, Phys. Rev. Letters 19, 759 (1967).

[2]J. N. Bahcall, W. L. W. Sargent, and M. Schmidt, Astrophys. J. 149, L11 (1967).

[3]J. Joly and E. Rutherford, Phil. Mag. 25, 644 (1913).

[4]R. V. Gentry, Appl. Phys. Letters 8, 65 (1966); Earth and Planetary Sci. Letters 1, 453 (1966).