

of the two uncertainties being of the order of Planck's constant  $h$ .\* Within the last two or three years, Professor Max Born has applied the principle of duality in an entirely new direction by his *Principle of Reciprocity*, which offers a prospect of unifying Quantum Theory with Relativity. The fundamental idea is that relativity effects are most in evidence when we consider the largest things—the expanding universe, etc.—while quantum effects are most in evidence in the smallest things. Born regards these as two extreme types of physical system, in one of which the space coordinates may take very large values, while in the other—nuclear phenomena—the spatial regions are very small but the energy and momenta concerned may be large. Thus between cosmical phenomena and nuclear phenomena there exists a duality corresponding precisely to Hamilton's duality between coordinates and momenta. In the hands of Born and his group of research students in Edinburgh, this idea is promising to yield the secret of the mysterious number 137.

Quantum-mechanical workers have generally tended to regard matrices rather than quaternions as the type of non-commutative algebra best suited to their problems but the original Hamiltonian formulae keep cropping up. Thus the "spin matrices" introduced by Pauli in 1927, on which the quantum-mechanical theory of rotations and angular momenta depend, are simply Hamilton's three quaternion units  $i, j, k$ . Professor Conway has shown in an interesting paper † that quaternion methods may be used with advantage in the discussion of Dirac's equation for the spinning electron: and the formalism of 1843 may even yet prove to be the most natural expression of the new physics.

E. T. W.

#### CORRESPONDENCE.

To the Editor of the *Mathematical Gazette*.

DEAR SIR,—In connexion with the article on Hamilton which you print elsewhere in this number of the *Gazette*, it would be of interest to ascertain whether Hamilton has any living descendants. He had only one grandchild, his daughter's son, John Rowan Hamilton O'Regan, born in 1870, who, when Graves' *Life of Hamilton* was published in 1889, was a scholar of Clifton College. Whether Mr. O'Regan is still living, and whether he married and had issue, I do not know. Perhaps through some Old Cliftonian, or organisation of Old Cliftonians, it might be possible to trace him and so settle the question.—I am, SIR, Yours truly,

E. T. WHITTAKER.

\* This discovery led to the publication of an enormous amount of nonsense about determinism and free-will. Actually the uncertainty-principle has nothing whatever to do with determinism or free-will: it simply expresses the fact that the classical concept of a particle (*i.e.* a very small body having a definite position and velocity) does not represent anything in nature: what is realised in nature is the quantum concept of a particle, which is something quite different.

† *Proc. R.S.*, 162 (1937), 145.