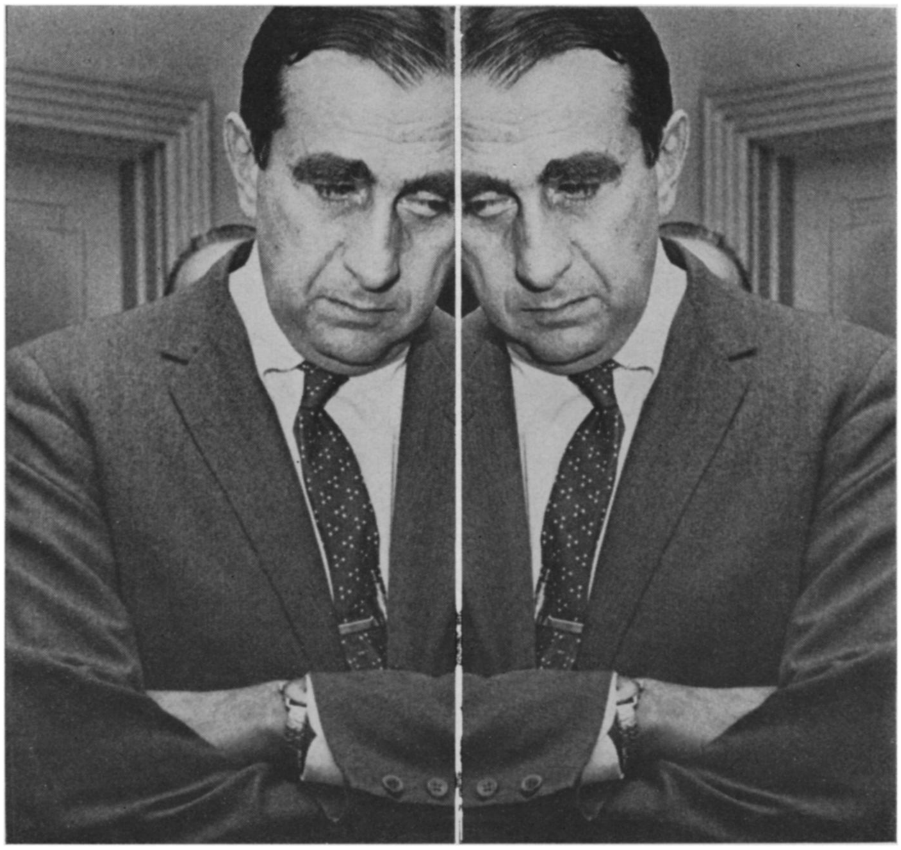
Well up beyond the
tropostrata
There is a region dark and
stellar
Where, on a streak of anti-
matter,
Lived Dr. Edward Anti-
Teller.

Remote from Fusion's origin
He lived unguessed and
unawares
With all his anti-kith and kin,
And kept macassars on his
chairs.

One morning, idling by the
sea,
He spied a tin of monstrous
girth
That bore three letters:
A.E.C.
Out stepped a visitor from
earth.

Then, shouting gladly o'er the
sands,
Met two who in their alien
ways
Were like as lentils. Their
right hands
Clasped, and the rest was
gamma rays.

Harold P. Furth



Marvin Lichtner

Drs. Teller and Anti-Teller would show parity reversal.

PARTICLES

Not-so-symmetrical symmetries

Nature should be balanced in three important respects but more and more imbalances are being found

by Dietrick E. Thomsen

Particle physicists have for years built their theories on the assumption that nature is symmetrical and balanced in three important respects: matter versus antimatter, left versus right, and going forward in time versus going backward in time.

If one takes a given experimental event, they believe, and changes particles to antiparticles, left to right, forward in time to backward, the result would be an event that can exist and is indistinguishable from the original one.

Though the general principle still seems to hold, nature turns out to be a little asymmetrical in respect to left and right and to matter and antimatter; uncertainty is spreading with regard to other parts of this symmetry system, as well.

The matter-antimatter reversal is called charge conjugation, or C, because it amounts to reversing the electric charges of the particles.

Parity conjugation, P, changes left to right, as does a reflection in a mirror; particles have a leftness or rightness that shows up in the mathematical form of the wave associated with them.

Time reversal, called T, is based on the notion that if a particle is looked on as an object going forward in time, its antiparticle can be considered as the same object going backwards.

For a long while it was believed that application of any one of these reversals, any two, or all three together would result in an interaction indistinguishable from the original.

But in the last few years, the system has been cracking, with respect to the

The present experimental status of the symmetries

Interaction	Symmetry				
	CPT	P	C	CP	T
Strong	✓	✓	✓	✓	✓
Electromagnetic	✓	✓	✓(?)	✓	✓(?)
Weak	✓	X	X	X	✓(?)

Physics Today

A symmetry checklist. X's are confirmed violations.

interactions governed by the so-called weak forces acting on subatomic particles. First P turned out to be asymmetrical, then C went, and most recently CP as a combination. So far no instances of T failure or CPT failure have been found, though physicists are sure that something has to be wrong with one or both of these since CP has turned out to be no good.

This failure of symmetry in the weak interactions was disturbing, and theories have had to adjust to it, but the weak subatomic force is an anomalous thing —nobody is sure why it should exist at all—and many were willing to accept that such a freak could be expected to behave freakishly in more ways than one. The strong and electromagnetic forces—the rocks on which theories of the structure of matter are built—were holding firm against any asymmetry at all.

But people kept looking, and now the latest result tends toward a conclusion that C may be violated in electromagnetic interactions as well. This, were incautious conclusions to be drawn from it, could have dramatic implications for physics theory. The work was reported in the Aug. 5 PHYSICAL REVIEW LETTERS.

The experiment, done by a Columbia University group led by Profs. Wonyong Lee, John Peoples and Claud Schultz, involves observations of the radioactive decay of the eta meson. This interaction is governed by the electromagnetic force, and in its products are a particle-antiparticle pair: the pi plus and pi minus.

If charge symmetry (C) holds, then in a large number of such decays the energy given to the particles should equal that given to the antiparticles.

But the result of 36,800 events recorded in experiments done at Brookhaven National Laboratory have shown an asymmetry of between one and two percent.

This result, which at least one observer considers on the edge of statistical significance, has been greeted very cautiously by physicists in the United States and abroad. First because this is a game of statistics in which more refined evidence and a greater number of experimental witnesses would help convince, and second because there has been at least one false alarm in the past: A 1966 claim that C had been shown to be violated was proved on further investigation to have been mistaken.

To be certain of their result the Columbia scientists would like to repeat and refine their experiment. Prof. Schultz says they would especially like to redo it in a way that would avoid the systematic biases of their present method. No experiment is free of systematic bias, but by choosing methods with differing biases, one can cancel their effects.

If physicists conclude that C is violated in this interaction and generally in the electromagnetic interactions, then the next thing to look for will be a violation of T. As Prof. Schultz puts it, they are firmly convinced that P is inviolate in the electromagnetic interactions. Therefore they would look for a violation of T that would compensate for that of C and save the combined invariance of CPT.

If T and C go down the drain, a good deal of theoretical adjustment will have to be made—especially in the neat one-for-one arrangement of particles and antiparticles. Some reason would have to be found why there is a greater abundance of one than the other. The problem, says Prof. Schultz, is "our emotional reluctance to do away with time reversal."

In the furthest extreme, CPT could go. That would bring down theoretical particle physics entirely, since the science is thoroughly based on the principle.

At present there is a great deal of evidence in support of CPT, and none against. Most physicists are still betting CPT will survive.