

The Rise and Fall of the Fifth Force: Discovery, Pursuit, and Justification in Modern Physics

Allan Franklin and Ephraim Fischbach

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Hints of fifth force in universe challenge Galileo's findings," proclaimed a front-page headline in the *New York Times* on 8 January 1986. Written by highly regarded science reporter John Noble Wilford, the article under it revealed that Purdue University's Ephraim Fischbach and colleagues had just published a paper revisiting early 20th-century torsion-balance experiments by Hungarian physicist Roland von Eötvös. Those experiments had helped establish the equivalence of gravitational and inertial mass. Fischbach and coauthors argued that the experiments also revealed subtle evidence for a new intermediate-range force supplementing the fundamental four: gravity, electromagnetism, and the strong and weak nuclear forces.

This "fifth force," as Wilford dubbed it, was about 1% as strong as gravity, extended roughly 100 meters, and could be carried by a light "hyperphoton" that coupled to baryon number. Because that force depended on a material's composition, it would have slightly altered the acceleration rates of the objects Galileo is said to have dropped from the Tower of Pisa.

Fischbach and University of Colorado historian of physics Allan Franklin independently relate the story of the fifth force in the second edition of Franklin's original book, *The Rise and Fall of the Fifth Force: Discovery, Pursuit, and Justification in Modern Physics*. Exposure in the nation's leading newspaper likely catapulted the new result into a prominence it would not have otherwise enjoyed. Wilford's article quickly elicited critical reactions from other physicists. Within days Richard Feynman and Sheldon Glashow had weighed in with disbelief. Others soon pointed out an omission in the authors' reasoning: Such composition-dependent forces could not have arisen unless there were large horizontal asymmetries in the local mass distribution near where the Eötvös experiments had occurred.

Those qualms, however, did not dissuade the experimenters who rose to the challenge of testing a new hypothesis

some considered plausible. Within a year three teams reported in with conflicting results. In one, Peter Thieberger of Brookhaven National Laboratory set a hollow copper sphere adrift in a temperature-controlled, magnetically isolated tank of water placed next to the Palisades in New Jersey. The sphere drifted steadily away from the cliffs, seeming evidence for a slight difference between the forces on water and copper. But a University of Washington experiment led by Eric Adelberger yielded null results. Using an extremely sensitive torsion balance, the Washington physicists suspended beryllium and copper cylinders pivoting about a central axis. Any composition-dependent force would have generated a tiny but measurable torque about that axis, but none was observed. Another University of Washington torsion-balance experiment gave positive results, but they disagreed numerically with Thieberger's conclusions.

In part, the experimental confusion reflected the limited understanding in the late 1980s of any deviations—which had been insufficiently measured—from Newton's inverse-square law at distances from 1 to 1000 meters. Only a few relevant experiments had been conducted, and they did not rule out deviations of up to a few percent. Some results had unattributed errors due, for example, to unaccounted-for mass asymmetries. But that area of experimentation rapidly improved during the late 1980s. By 1990, according to the authors, the fifth force was on its knees. A year later it was dead, with the great preponder-



ance of evidence weighing against its possible existence.

So was all the experimental—and theoretical—effort a waste of time? Not at all, says Franklin in his new discussion. For one, the search for small intermediate- and short-range deviations had an effect on particle-physics theory, particularly on theories of charge conjugation-parity violation and string theories that required such discrepancies. It especially honed physicists' abilities to design and interpret the increasingly precise experiments needed to evaluate such theoretical work.

For scholars of science, argues Franklin, the search also provided a laboratory in which to study what he calls the "context of pursuit." That kind of research activity arises when a hypothesis is sufficiently plausible, and the experimentation costs sufficiently modest, for interested physicists to pursue appropriate measurements despite the likelihood of obtaining a null result. Appearance in the *New York Times* helps, too.

The publication of this revised edition, which includes updates on theory developments and experiments performed since 1991, is very welcome. Fischbach's section gives a detailed, subjective account of his work from 1985 to 1991, the period of his most intense activity on the fifth force. The revised edition serves as a valuable counterweight to Franklin's original account, included in the book, which was dense, compact, and difficult for the uninitiated to follow. I just wish the publisher had kept the book's cost below \$100, for only the fervid few will judge its contents worth its high price.

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Colour How We See It and How We Use It

Michael Mark Woolfson

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Michael Mark Woolfson, a professor emeritus at the University of York in the UK, has had a long and distinguished career researching x-ray crys-

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