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The discovery of Maxwell's equations

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In January 1865, Maxwell at age 34 wrote a letter to his cousin Charles Cay describing various doings, including his work on the viscosity of gases and a visit from two of the world's leading oculists to inspect the eyes of his dog "Spice". He added, "I have also a paper afloat, with an electromagnetic theory of light, which, till I am convinced to the contrary, I hold to be great guns." That paper "A Dynamical Theory of the Electromagnetic Field" was his fourth on the subject. It was followed in 1868 by another, and then in 1873 by his massive two volume Treatise on Electricity and Magnetism. Even so, by the time of his death in 1879 as he was beginning a radically revised edition of the Treatise, much remained to be done. We celebrate here the 150^{th} anniversary of Maxwell's first astonished realization in 1862 of the link between electromagnetism and light. So revolutionary was this that 15 or more years went by before Lorentz, Poynting, FitzGerald, and others came to address it, sometimes with improvements, sometimes not. Not until 1888 did Hertz make the essential experimental discovery of radio waves. What is so remarkable about Maxwell's five papers is that each presents a complete view of the subject radically different from the one before. I shall say something about each, emphasizing in particular Maxwell's most unexpected idea, the displacement current, so vastly more interesting than the accounts of it found in textbooks today. Beyond lie other surprises. The concept of gauge invariance, and the role the vector potential would play in defining the canonical momentum of the electron, both go back to Maxwell. In 1872 came a paper "On the Mathematical Classification of Physical Quantities", which stands as an education in itself. Amid much else, there for the first time appears the distinction between axial and polar vectors and those new operational concepts related to quaternion theory: *curl, divergence,* and *gradient.*