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Minkowski and the concept of 4-space FELIX T. SMITH, Retired — After Lorentz (1904) showed the invariance of the equations of electricity and magnetism under the Lorentz transformation (L.T.) in space and time, Minkowski in 1905 discovered how all this could be simply and symmetrically presented through the vectors and matrices in a 4-space, which he formulated as a space-time with the roles of all 4 components essentially equivalent. Poincaré did not accept this, believing other structures compatible with L.T. but with a separable 3-space and time could also be found. Minkowski himself discovered the still standard form of the relativistic 4-velocity, whose 4 components are confined to a curved 3-space by the constraint of constant c. A similar construction can be identified in position 3-space if the upper bound c is paralleled by the upper bound of a time-dependent Hubble length. This leads to the alternative possibility of formulating a new version of special relativity in terms not of a flat 4-space, but of a negatively curved 3-space, where the 4th term arises from the Hubble expansion.

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