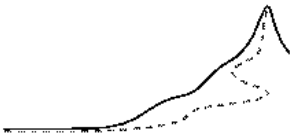

Chapter II

SPECIAL RELATIVITY

There are limitations on motion that are missed by the Galilean description. The first limitation we discover is the existence of a maximal speed in nature. The maximum speed implies many fascinating results: it leads to observer-varying time and length intervals, to an intimate relation between mass and energy, and to the existence of event horizons. We explore them now.

5. MAXIMUM SPEED, OBSERVERS AT REST, AND MOTION OF LIGHT

«Fama nihil est celerius.»*

Light is indispensable for a precise description of motion. To check whether a line or a path of motion is straight, we must look along it; in other words, we use light to define straightness. How do we decide whether a plane is flat? We look across it,** again using light. How do we measure length to high precision? With light. How do we measure time to high precision? With light: once it was light from the Sun that was used; nowadays it is light from caesium atoms.

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In other words, light is important because it is the standard for *undisturbed motion*. Physics would have evolved much more rapidly if, at some earlier time, light propagation had been recognized as the ideal example of motion.

But is light really a phenomenon of motion? This was already known in ancient Greece, from a simple daily phenomenon, the *shadow*. Shadows prove that light is a moving entity, emanating from the light source, and moving in straight lines.*** The obvious conclusion that light takes a certain amount of time to travel from the source to the surface

* 'Nothing is faster than rumour.' This common sentence is a simplified version of Virgil's phrase: *fama, malum qua non aliud velocius ullum*. 'Rumour, the evil faster than all.' From the *Aeneid*, book IV, verses 173 and 174.

** Note that looking along the plane from all sides is not sufficient for this: a surface that a light beam touches right along its length in *all* directions does not need to be flat. Can you give an example? One needs other methods to check flatness with light. Can you specify one?

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*** Whenever a source produces shadows, the emitted entities are called *rays* or *radiation*. Apart from light, other examples of radiation discovered through shadows were *infrared rays* and *ultraviolet rays*, which emanate from most light sources together with visible light, and *cathode rays*, which were found to be to the motion of a new particle, the *electron*. Shadows also led to the discovery of *X-rays*, which again turned out to be a version of light, with high frequency. *Channel rays* were also discovered via their shadows; they turn out to be travelling ionized atoms. The three types of radioactivity, namely *α-rays* (helium nuclei), *β-rays*