

# Preface

This book contains reprints of articles on various facets of teaching relativity theory, with its symmetry principles, conservation laws of energy  $E$ , momentum  $\mathbf{p}$  and mass  $m$ , and the fundamental kinematic equation,  $(E/c^2)^2 - (\mathbf{p}/c)^2 = m^2$ , where  $c$  is the velocity of light.

This fundamental equation has been tested again and again in various experiments with radioactive substances, cosmic rays and particle accelerators. It is equally applicable to massive particles, such as protons and electrons, to very light neutrinos and to massless particles of light — photons. From this equation, when  $\mathbf{p} = 0$ , Einstein's great formula follows:  $E_0 = mc^2$ , according to which even a small mass contains a huge energy in the form of rest energy  $E_0$ .

Doing physics research is like climbing a mountain; to see the path to the truth, one has to look down from the standpoint of higher, advanced knowledge. In the case of relativity this standpoint — the vantage ground of truth — was found by Minkowski, who united time  $t$  and space  $\mathbf{r}$  into a single four-dimensional world. Similarly,  $E/c^2$  and  $\mathbf{p}/c$  are united in a four-dimensional vector, for which  $m$  is its pseudo-Euclidean length.

If one attempts to pour the new wine of relativistic four-dimensional physics into an old wineskin of three-dimensional Newtonian formulas, one ends up with such confusing terms as “relativistic mass” and “rest mass” and the famous but misleading equation  $E = mc^2$  which differs from Einstein's true equation by the absence of subscript zero.

This famous equation and the concept of mass increasing with velocity indoctrinate teenagers through the popular science literature, and through college text-books. According to Einstein, “common sense is a collection of prejudices acquired by age eighteen. “It is very difficult to get rid of this “common sense” later: “better untaught than ill taught.” As a result one can find the term “rest mass” even in serious professional physics journals. One of the aims of this book is to help the reader to get out of the habit of using this term.

I am grateful to Professor K. K. Phua, who invited me to publish this book, and to Mister Chee-Hok Lim, who carefully edited it.

The book consists of 30 articles published over the course of 40 years (1968–2008). The three most recent papers resulted from attempts to write this preface. They elaborate on the historical evolution of the concepts of energy, momentum and mass

from the standpoint of relativity principle, and suggest a simple method of deriving the main results of both special and general relativity. They acknowledge those who helped me to write these papers and hence this book.

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