Many-Body Problem Encyclopedia Article

Many-Body Problem

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Contents

Many-Body Problem Encyclopedia Article.....1

Contents.....2

Many-Body Problem.....3

Many-Body Problem

The many-body problem involves describing a large number of interacting particles in a detailed way and, specifically, in a way that predicts their future behavior. In all of physics, there are few issues stated so simply, but the many-body problem is responsible for as many headaches as any other. In fact, the problem has not been completely solved, and it may never be. As with relations between people, interactions between particles, or bodies, become increasingly complex when more than one get involved. The many-body problem is not concerned with the bodies in and of themselves, for these can be successfully described; the central issue and the real difficulty lie in the effects that these particles have on one another. One body moving through **space** is easily understood and its future is predictable. When many bodies are involved, however, keeping track of their interactions quickly becomes nightmarish.

A simple many-body example appears in certain lotteries where a tumbler of numbered Ping-Pong balls determines winning numbers. Say there are 100 such balls in a large, rotatable drum. Even if the exact position of each ball is know in the beginning, it is virtually impossible to predict which number will sit on top after the drum rotates a few dozen times. The Ping-Pong balls are obviously interacting. When they collide, they bounce from one another, changing directions. It is these interactions that make for such a wild, umpredictable scene inside the drum and leave the lottery with a practically random result.

Fundamental particles (such as electrons) make for a much more challenging instance of the many-body problem because their interactions are more varied and complicated than those of Ping-Pong balls. Physicists can take on quite a few Ping-Pong balls before running into trouble, but they have their hands full when they consider only two fundamental particles.

Many-body literature has turned increasingly to the use of **Feynman diagrams** in the 30 years. These diagrams, introduced by Richard P. Feynman, give physicists an elegant pictorial shorthand for complicated mathematical expressions. They involve a simple set of symbols (dots, arrows, various lines) and a short but rigid list of rules. Many-body physicists can carry on entire conversations and arguments using nothing more than these quick sketches.