

adopt it. The main point is that there is a greater inertial resistance to velocity changes (whether an increase or a decrease) along the direction of motion, compared to the inertial resistance to picking up a velocity component transverse to the current motion (and both exceed the inertia of the rest mass).

One can also use eqn (2.56) in eqn (4.9), giving

$$\mathbf{f} = \gamma m_0 \left(\mathbf{a} + \gamma^2 \frac{\mathbf{u} \cdot \mathbf{a}}{c^2} \mathbf{u} \right) = \gamma^3 m_0 \left((1 - u^2/c^2) \mathbf{a} + \frac{\mathbf{u} \cdot \mathbf{a}}{c^2} \mathbf{u} \right). \quad (4.14)$$

This allows one to obtain the longitudinal and transverse acceleration without an appeal to work and energy.

The 'instantaneous rest frame'

The notion of an 'instantaneous rest frame' has to be correctly understood in the case of a particle undergoing acceleration. It does not refer to an accelerating reference frame, but to a sequence of inertial reference frames.

For a particle undergoing any type of motion, one can always talk about the 'rest frame' of the particle for any given event A on the particle's worldline. This is the inertial reference frame in which the velocity of the particle is zero at event A . Let us call this frame S_A . This reference frame is moving inertially—at constant velocity—whether or not the particle is. If the particle is accelerating at event A , then it is at rest in S_A only momentarily. That does not mean S_A is a non-inertial frame, it just means that immediately before and after A the frame S_A is not the particle's rest frame.

We can imagine a continuous set of inertial reference frames moving around in any region of space. Each has constant velocity. As a given particle accelerates through the space, its rest frame is now one member of the set, now another. When we speak of 'the instantaneous rest frame' it means whichever inertial frame in the set is the rest frame at the event under consideration. One may then naturally extend this idea to a sequence of events, and then the phrase 'the instantaneous rest frame' refers to a sequence of inertial frames; it is purely and simply a shorthand phrase for 'the sequence of instantaneous rest frames'.

4.2.1 Linear motion and rapidity

For a particle undergoing straight-line motion, the rapidity is often a useful quantity to consider. This is because for this case there is a simple relationship between rapidity in one frame and another.

Consider a particle accelerating along a line. That is, the velocity is aligned with the acceleration, and the acceleration is always in the same direction (but not necessarily of constant size). Let S_A be the instantaneous rest frame at some event A (see box above). At A the particle