Chapter 2: Speed

The concept of velocity, like time, is one of the most fundamental concepts in physics. However, existing knowledge of physics has been severely flawed in its understanding of velocity, leading to the development of erroneous theories such as relativity. This paper will illustrate how precarious the understanding of velocity, a cornerstone of physics, has been. We will then present specific examples and explain the correct concept of velocity.

2.1 Velocity and Relative Velocity

According to the general view of physicists, velocity is a relative concept, and the velocity of an object is defined by its relative velocity with respect to some reference (e.g., an inertial coordinate system). On the other hand, relative velocity is defined by a form that includes velocity. Since velocity is defined by relative velocity, using velocity to define relative velocity contradicts the method of definition and is not a correct definition. The ambiguity in the conventional understanding of the concepts of velocity and relative velocity leads to difficulties in understanding theories that use relative velocity. Relative velocity and velocity must be correctly redefined.

According to the general view of physicists, it is completely meaningless to ask what the velocity of a single point mass P is when there is nothing else around it. This is because, without something to compare it to, it is impossible to measure the velocity of point mass P.

Given two point masses P and Q, we can consider the speed of Q relative to P and the velocity of P relative to Q. Generally speaking, when considering velocity, at least two points are necessary.

The velocity of Q relative to P is the rate of change over time of the position vector from P to Q, with P considered as the coordinate origin. That is,

$$\boldsymbol{V}_q = \frac{d\boldsymbol{r}_q}{dt} \qquad (2.1)$$

V_q is the velocity of Q relative to P,

and r_q is the position vector from P to Q.

This is expressed as. Here, the question arises as to how to measure the change in the position vector, but we have decided that specifying it in detail is not very important in this case and will omit it, assuming that it can be measured according to the general concept of coordinates.

Conversely, the velocity Vp of P relative to Q is given by rp as the position vector,

$$\boldsymbol{V}_p = \frac{d\boldsymbol{r}_p}{dt} \qquad (2.2)$$

This is the result. Clearly $\boldsymbol{r}_p = -\boldsymbol{r}_q$

$$\boldsymbol{V}_q = -\boldsymbol{V}_p \qquad (2.3)$$

Therefore, V_q is equal to the relative velocity of Q with respect to P. Although velocity and relative velocity are generally defined as different things, in practice they represent the same thing. To put it differently, velocity is the relative velocity with respect to the coordinate origin. Since we have found that what is generally called velocity is the same as relative velocity, in order to distinguish it from other forms of velocity that will be defined later, we will not distinguish between velocity and relative velocity and will simply call it relative velocity. Velocity is the relative velocity with respect to the coordinate origin, but in case it is necessary to distinguish this from relative velocity in the ordinary sense, we will also call velocity coordinate velocity. Furthermore, we will call the further time derivative of relative velocity relative acceleration, and that of coordinate velocity coordinate acceleration, and so on.

When using relative velocity, V_q and V_p are completely equivalent and indistinguishable except for their opposite directions. In other words, the definition of relative velocity is neither more nor less than this, and any conclusion drawn from using relative velocity that claims any difference arises in the states of P and Q is a deviation from the definition of relative velocity, and such conclusion will contain a contradiction.

2.2 Acceleration without using relative quantities

Assume that two spacecraft P and Q are floating in outer space where the influence of gravity from other sources is negligible. Only P and Q exist in this space, and for an observer inside P and Q, P can see Q, and Q can see P, but nothing else is visible. Initially, P and Q are separated by a small distance, and this distance does not change. Therefore, the relative velocity between P and Q is zero.

Next, suppose one of the spacecraft, P or Q, fires its rocket and accelerates. At this point, would an observer inside P or Q be able to tell which one has been accelerated?

From point P's perspective, Q appears to be moving away from P with an observed relative acceleration. Similarly, from point Q's perspective, P also appears to be moving away from Q with an observed relative acceleration.

If the magnitude of this relative acceleration is A, then the relative acceleration between P and Q is A.

People like Mach, Poincaré, and Einstein would surely answer as follows:

"We have always defined concepts such as the position and velocity of an object by comparing them to the position and velocity of other objects. In this case, the objects of comparison are only Q for P and only P for Q. In this case, the observed relative acceleration is exactly the same for both P and Q, except that the direction is opposite. Therefore, if we use P as the reference, Q is accelerated, and if we use Q as the reference, P is accelerated. Therefore, since the motions of P and Q are observed in exactly the same way, there is no way, and it is impossible, to distinguish which one was accelerated." Thinking in this way is perfectly correct if we consider this phenomenon using existing knowledge of physics. This is because, according to the general view of physicists, absolute velocity and absolute acceleration are denied.

However, astute readers will have already noticed this. "An observer at points P and Q can tell which is being accelerated. When you're in an accelerating car, you feel your body being pressed against the seat. Such a force should also be present for an observer inside a spaceship, and an observer inside a spaceship should be able to tell whether their spaceship is being accelerated or not." That's right. If an accelerometer is installed inside the spaceship, it's possible to know exactly how much acceleration has occurred without having to look outside the spaceship.

One might think that Einstein was the first to say something like this. Indeed, Einstein said that if you pull on an elevator floating in outer space, the apple inside will fall out. However, this is fundamentally contradictory to the concept of relativity.

If we assume that velocity only has relative velocity, then we can conclude that acceleration, which is its time derivative, is only relative acceleration. However, the concept of relative acceleration did not provide a way to determine whether P or Q was moving. In contrast, in reality, there is a way to determine which of P or Q was moving by using an accelerometer.

Therefore, the quantity of the accelerometer reading used in this case is clearly not the same as the quantity of relative acceleration. Since the quantity of the accelerometer reading and the quantity of relative acceleration show different values, it is natural that they cannot be defined as the same quantity.

2.3 Velocity measured by an accelerometer

Generally, measuring displacement and velocity requires a reference point located at a different spatial position. Acceleration, which is the further time derivative of velocity, can be measured without the need for a reference point by measuring the value of an accelerometer. This measuring instrument does not track the spatial coordinate displacement of a moving object, but rather measures the acceleration of a moving object by being installed inside the object.

It is empirically known within the realm of Newtonian mechanics that, in certain cases, when this accelerometer is placed inside an object P and accelerated by a non-gravity method, the value of the accelerometer is equal to the value of the relative acceleration observed using a coordinate system that considers object Q as the origin of the coordinate system. Here, "certain cases" refers to the case where the initial conditions (the relative velocities of P and Q are set to zero) are consistent in each observation. From the value of this accelerometer, velocity, displacement, and momentum can be easily determined. To distinguish these physical quantities from those measured relative and coordinately, let us call them inertial acceleration, inertial velocity, inertial displacement, and inertial momentum, respectively. As is well known, the method for determining inertial velocity and inertial displacement from inertial acceleration is to integrate the acceleration.

$$\begin{aligned} \boldsymbol{V}(t) &= \int_0^t \boldsymbol{A}(t)dt \\ \boldsymbol{r}(t) &= \int_0^t \boldsymbol{V}(t)dt \end{aligned} \qquad (2.4)$$

A(t) is inertial acceleration, V(t) is inertial velocity,

r(t) is inertial displacement,

It is given by this. Now, let's assume that an accelerometer is also installed inside object Q, but it is not being accelerated. In this case, the sum of the accelerometer readings inside Q is zero, and from this, we can see that the inertial acceleration and inertial velocity are also zero. When viewed from P to Q, there will be relative acceleration and relative velocity, but a clear difference can be found between P and Q in terms of inertial acceleration and inertial velocity.

Relative velocity and relative acceleration, which only indicate relative positional relationships, cannot be used to claim any difference in the states of P and Q. This is because relative velocity changes in any way depending on the choice of coordinates, and since the choice of coordinates is arbitrary, the magnitude of the relative velocity and the state of the moving object are not directly related.

Inertial velocity does not require comparison with other quantities in its measurement. A quantity determined without comparison with other quantities can be considered an absolute quantity in relation to a relative quantity. An absolute quantity is a quantity that can describe a state. Using this quantity, a clear difference can be shown between P and Q, so they cannot be treated as equivalent and can be considered to be physically different states.

The force that changes the value of this accelerometer is what physicists call an apparent force. However, the expression "apparent" is highly inappropriate for a physical quantity that can actually exert force on an object. Existing physical knowledge is also wrong in terms of this understanding of force, but we will discuss this in Chapter 9.

2.4 Relationship between inertial velocity and coordinate velocity

As an initial condition, when we set up an object with zero inertial acceleration and a coordinate system with zero relative velocity to that object, it is empirically known that the inertial velocity of this object is equal to the relative velocity using this coordinate system within the realm of Newtonian mechanics. Using a coordinate system defined in this way, the position and velocity of an object can also be measured using relative quantities with respect to this coordinate system. If we call such relative quantities inertial coordinate velocity, then inertial velocity and inertial coordinate velocity are equal.

When using relative velocity, the coordinate system can be set arbitrarily, and the coordinate system can be changed arbitrarily. However, the coordinate system used in inertial coordinate velocity cannot be changed arbitrarily. This is because inertial coordinate velocity can absolutely express the motion of an object within that coordinate system, but if the coordinate system is changed, the quantities used in that coordinate system become relative quantities.

Furthermore, to distinguish the relative velocity between inertial velocities from ordinary relative velocity, let's refer to it as inertial relative velocity.

This chapter does not cover all concepts related to speed. We will discuss these concepts further in subsequent chapters as needed.