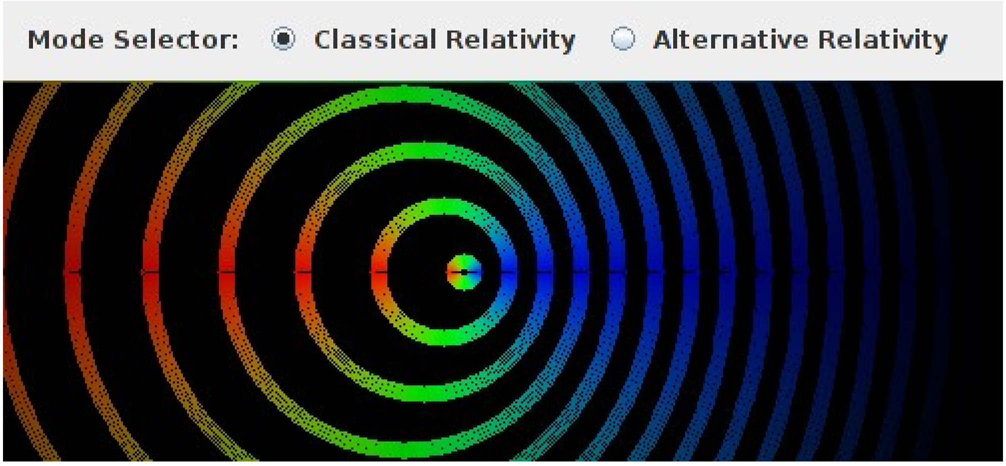
The Nature of Light: The Doppler Effect



Colour Shift

The colour of light is described as hotter towards the bluer end of the spectrum and cooler towards the redder end of the spectrum. Most objects reflect light that is of a "cooler colour" than the incident light from which it is generated. The reflected light from an efficient reflector returns light that is closer to the "colour temperature" of the incident light. A silver mirror reflects light of a colour that is extremely close to that of the incident light. Let us assume, for the sake of clarity in the following discourse, that our mirror is 100% efficient in this sense. The light it reflects (or re-emits) is exactly the same colour as the light it receives.

Despite the above assumption, if the mirror is receding from the source of the incident light, the light it reflects is of a "cooler colour" than the light it receives. The amount by which the reflected light is "cooler" than the incident light depends on the relative velocity with which the source and the mirror are receding from each other. This *shift* of the reflected light towards the redder end of the light-spectrum is generally known as the *Doppler Effect.*

The Case of Sound Waves

The Doppler Effect is readily observable for sound waves. One example is the horn of a car. The horn has a natural or "normal" pitch. This is how it sounds when the car is stationary. However, if the car approaches you and then passes you at high speed, the sound changes. The pitch of the horn is higher than normal while the car is approaching. At the instant it passes you, the pitch of its sound is normal. As the car recedes, the pitch of its horn becomes lower than normal.

The same thing is experienced with the sound source stationary and the listener moving.

The mechanism of this phenomenon is easy to explain for sound waves. This is because sound travels within the medium of air. Its velocity is therefore tied to the *frame of reference* of the stationary air. The velocity of the sound source is also measured against the *frame of reference* of the air in which the sound travels.

The above applet in its default "Classical Relativity" mode illustrates the Doppler Effect for sound waves. Both the observer and the transmittal medium (air) are stationary with respect to the applet window.

The crests of the sound waves emitted in front of the source are shown in blue. They arrive at the observer on the right of the applet window in more rapid succession than they are emitted by the source. This has the effect of giving the sound an apparently higher frequency (or pitch).

The crests of the sound waves emitted behind the source are shown in red. These impact the ears of an observer on the left of the screen with less rapidity than the source emits them. This has the effect of lowering the apparent frequency (or pitch) of the sound.

Waves emitted either side of the source are shown in green. Their crests impact the top and bottom of the applet window with the same rapidity as the source emits them. This means that an observer at the top or bottom of the applet window will hear the sound source at its normal frequency (or pitch).

Imagine an observer standing where the "Classical Relativity" selector button is at the top of the applet window. As the source passes, you can see that he is first impacted by blue waves which gradually transform into green and then into red. This observer will therefore hear a high pitch gradually lowering to normal and then lowering further as the source recedes.

The Case of Light Waves

The Doppler Effect is also observable for electromagnetic waves. In fact, some navigation systems use the Doppler Effect in radio waves as a means of determining the distance travelled by an aircraft. So the effect is definitely real. However, the Doppler Effect is *not easy* to explain for electromagnetic waves. Established theory assumes that an electromagnetic wave leaves its source with an outbound velocity **c** - the universally constant velocity of light. It also assumes that an electromagnetic wave approaches and "impacts" its destination (observer) at the same universally constant velocity **c**.

The established explanation is that the Doppler Effect for light is essentially the same as for sound. Waves emitted in the direction of the source's motion are compressed and those emitted in the opposite direction are rarefied, as show by the above applet in "Classical Relativity" mode. The source is actually emitting only green light.

The reason given, however, is that within the frame of reference of a receding observer, space becomes contracted and time becomes dilated in the direction of the source's motion. Conversely, within the frame of reference of an approaching observer, space becomes elongated and time becomes compressed in the direction of the source's motion. The effect created is essentially the same as if each observer had his own private all-pervading luminiferous aether that was stationary with respect to him.

An interesting consequence of this explanation is that within an approaching observer's space, the electromagnetic waves in transit are really vibrating at a higher (blue-shifted) frequency. Conversely, within a receding observer's space, the electromagnetic waves in transit are really vibrating at a lower (red-shifted) frequency. Can a passive observer really affect the frequency of electromagnetic waves that have not yet reached him, or the space within which they are travelling towards him?

Without postulating a contraction of space and dilation of time between the frames of reference of the light's source and destination, it is practically impossible to propose any explanation of the Doppler Effect for light if its velocity is deemed to be a constant **c** in all frames of reference.

An Alternative Explanation

I propose that the velocity of light is always the universal constant **c** relative only to the frame of reference of its source. This makes the mechanism of the Doppler Effect easy to explain.

Please select the "Alternative Relativity" mode by clicking the appropriate button at the top of the above applet. You might have to click it twice, depending on which browser you are using. The applet now shows the same green source emitting light waves. Now, however, the waves move outwards *from the source* at the constant universal velocity **c**, irrespective of any observer's frame of reference.

Light waves oscillate at a certain frequency. This frequency is determined by the light-source. It corresponds to the colour of the light. It is the rate at which the amplitude of the electric force field of the light wave changes from zero through maximum positive, back to zero and to maximum negative and back to zero again. As before, an observer, who is "stationary" relative to the source, experiences the light as having the frequency with which the source emitted it.

Now look at how the waves emitted by the moving source arrive at the left-hand side of the applet window. We may regard the left-hand side of the applet window as a receding observer. Waves are arriving at the left-hand side of the applet window less frequently than they are being emitted by the source. To an observer here, the light will therefore appear to be of a lower frequency. It will appear redder, even though it in fact travelled all the way from the source to the observer as green light. The light appears to be red-shifted according to the Doppler Effect.

Now look at how the waves emitted by the moving source arrive at the right-hand side of the applet window. We may regard the right-hand side of the applet window as an approaching observer. Waves are arriving at the right-hand side of the applet window more frequently than they are being emitted by the source. To an observer here, the light will therefore appear to be of a higher frequency. It will appear bluer, even though it in fact travelled all the way from the source to the observer as green light. The light appears to be blue-shifted according to the Doppler Effect.

This alternative view does not require separately contracted space and dilated time for every possible observer that exists or could exist. It simply requires that electromagnetic waves travel at the universal velocity **c** with respect to the source that created them. It simply requires that an electromagnetic stress applied at a point in space be adopted by the space surrounding that point with such a reluctance that causes it to effectively propagate outwards with velocity **c**. And that this process is independent of the velocity of the source relative to anything else.

Of course, if, having emitted light, the source then accelerates, that is a different story. The outward propagation would then be as if from the point in space that continued in the uniform motion the source had at the instant the light was emitted.

The Ætherial View

In my seven essays about The Universe [see side panel], I gradually built up an observer-centred view based on the notion that the universe is made of an all-pervading velocity fluid, which I refer to as the æther. I call it a velocity fluid because it can only exist while travelling at the speed of light. Furthermore, it only manifests itself to objects that are accelerating. It does not interact in any way with objects travelling at constant relative velocity. It flows convergently, at the speed of light, into nanoscopic sink-holes at the centres of all fundamental constituents of matter, including all observers.

In this view, which is expounded fully in my essay entitled Events and Waves, a light-source simply etches electromagnetic stresses into the observer's passing ætherial influx. The passing æther flows radially inwards towards the observer at the speed of light, carrying the electromagnetic etchings with it, and thereby giving us our perception of time.

Please select the original "Classical Relativity" mode, in which the applet started, by clicking the appropriate button at the top of the above applet. This also illustrates how the light will travel if the source simply etches it onto the passing ætherial flux which is falling radially inwards, at the speed of light, towards and into the observer - wherever he may be located. Consequently, the Ætherial View is entirely consistent with the Doppler Effect for electromagnetic propagation.

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source code: applet, display, wave.