the speed of light. The same is true of soundwaves, which do not travel faster or slower because of the motion of the emitting source of the sound. However, the motion of the object emitting sound or light waves is still obvious and measurable because the motion does have an effect on the light or sound waves.

Doppler shifting describes the properties of waves undergoing motion. Waves can be compressed or expanded, depending on whether an object is moving toward or away from an observer. If a star is moving toward an observer, that stellar light will still travel at its constant speed (the speed of light) but its wavelength will be compressed (the energy of the moving object will be expressed by a compression of the light wave peaks). Every emitted wavelength will become "blue-shifted" (with the photons moving to shorter wavelengths, with blue considered "short" wavelength visible light). If a star is moving away from an observer, the velocity of the star will elongate the photon wavelengths; longer wavelengths mean "redder" photons and hence "red-shifted light." So the well-known and laboratory-measured spectral lines of a star will occur at longer wavelength or shorter wavelength, respectively. Since astronomers know the wavelength of certain spectral lines to very high precision, such as the hydrogen alpha line, at 6563 Å. By comparing these rest, unshifted wavelengths to Doppler shifted wavelengths, astronomers can make measurements of the actual motion an object is undergoing, even though this approach is restricted to radial motions (see below).

The Doppler shift is critical to astronomy given the huge distances and small apparent sizes of objects in the Universe. For example, stars orbit the center of galaxies at high velocities but – given the size of a star's orbit – it may take hundreds of millions of years to complete one orbit. Therefore, over the course of a human lifetime, the largest telescope on Earth would not see a star in a galaxy move even the smallest amount. However, the star's velocity can still be calculated by measuring the shift in the stellar light from its rest wavelength pertaining to known nearby stars. Astronomers can use the presence of multiple sets of spectral lines to determine that a single blob of light may actually represent two orbiting stars. The rhythmic shift in spectral lines of a star may perhaps also be the telltale sign of an unseen component tugging on the star, such as the minor tug of an extra-solar planet or the powerful pull of an orbiting black hole companion.

EQUATIONS AND CONSTANTS

Equation	Expression	Variables
Doppler Shift	$\Delta\lambda = \lambda_{obs} - \lambda_0$	$\Delta\lambda$: the Doppler shift λ_{obs}: the observed wavelength of a spectral line λ_0: the laboratory, rest wavelength λ_0: the laboratory, rest wavelength
Radial Velocity	$v_R = \dfrac{\Delta\lambda \times c}{\lambda_0}$	v_R: the radial velocity $\Delta\lambda$: the Doppler shift λ_0: the laboratory, rest wavelength c: the speed of light
Constants and Conversions		
$c = 299{,}792.458\,\dfrac{km}{s} \approx 300{,}000\,\dfrac{km}{s}$		