

## When is light a ray and when is it a wave?

Ray theory exactly predicts the path light takes, so we can measure distances in space.

Ray theory exactly predicts reflection and refraction, so that we can design mirrors and lenses to do just what we want, in such applications as:

- Building a telescope, camera, or microscope,
- correcting visual refractive errors, or
- letting us see the other cars behind us when we drive.

Ray theory does not do a particularly good job of *explaining* reflection or refraction, however.

Worse, ray theory makes exactly the wrong prediction about what happens to light passing through very small openings. The patterns that we see when light passes through one or two slits can be easily explained as the diffraction patterns of waves. When we imagine light to be a wave, we find we can explain not only these slit patterns, but refraction as well. Similarly, if we think of the different refrangibilities of the rays of light as different wavelengths, we can easily explain the production of a spectrum from a diffraction grating (as well as why such a spectrum is like a prism-made turned “inside out”).

If we imagine the ray as simply the normal to the wave (that is, the direction the wave is traveling), then we can happily keep all our ray optics (except the wrong two-slit prediction, of course) intact.