Atmospheric refraction of light

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For most optical experiments at School level, it is not essential to distinguish between the velocity of light in so-called "free space" (in vacuo) and that in air. That is, we assume:

$$\frac{\text{velocity of light in vacuo}}{\text{velocity of light in air}} = 1$$

The actual difference is small, but extremely important, in Astronomy. The connexion between the refractive index and the density of a gas is expressed fairly closely by the equation

$$\boxed{\frac{n-1}{d} = \text{constant}}$$

The Dale and Gladstone Law

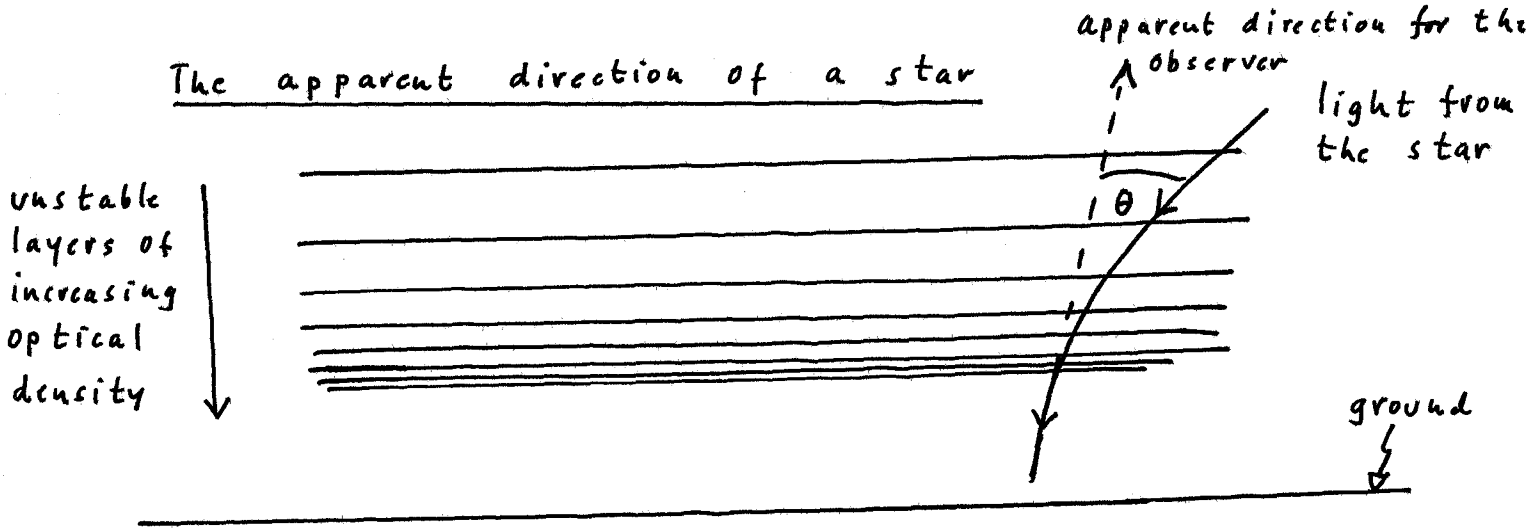
For example, at 0°C, $\frac{\text{velocity of light in vacuo}}{\text{velocity of light in air}} = 1{\cdot}00029$

And at 20°C, $\frac{\text{velocity of light in vacuo}}{\text{velocity of light in air}} = 1{\cdot}00028$

We can think of the atmosphere as made up as a series of unstable layers, on top of one another, each with a refractive index a little less than the one below it.

Light entering the atmosphere from (say) a star will have its velocity <u>gradually</u> reduced and be refracted more and more towards the normal, from one layer to the next. Glass, on the other hand, has the same optical density throughout, so the reduction in the velocity of light is <u>abrupt</u>; this reduced velocity is constant during the passage of light through the glass, as is Lr (Incidentally, the lens of your eye <u>does not</u> have a uniform refractive index: it varies from the centre to the surface, partly enabling the lens to correct for chromatic aberration.) The light will follow a curved path. c.f. with the refracted ray in your glass block experiment, where $\frac{\text{velocity of light in vacuo}}{\text{velocity of light in glass}} = 1{\cdot}5$

The apparent direction of a star



The value of θ will be zero for a star directly overhead and increase to its greatest value, about 0·5°, for a celestial object on the observer's horizon. <u>This angle is slightly greater than the angular diameter of the Sun, so when the setting (or rising) Sun is seen on the horizon, the whole of the disc is really below it.</u>

So, we "see" (a virtual image) two minutes before the Sun rises and two minutes after it has set. That is, four extra minutes of Solar visibility, each day.

The currents of hot air rising from a heated surface cause objects viewed through them to "shimmer," as the hot air has a lower refractive index than the surrounding atmosphere. The twinkling of stars is due to small irregularities in the density of the atmosphere.

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① $\frac{\text{Velocity of light in air}}{\text{Velocity of light in water}} = 1{\cdot}33$. That is, ${}_{a}n_{w} = 1{\cdot}33$

② ${}_{a}n_{g} = 1{\cdot}5(2)$

③ ${}_{\text{air}}n_{\text{diamond}} = 2{\cdot}4(4)$

④ ${}_{\text{air}}n_{\text{olive oil}} = 1{\cdot}4(8)$

⑤ ${}_{\text{air}}n_{\text{turpentine}} = 1{\cdot}4(8)$

⑥ ${}_{\text{air}}n_{\text{bromine}} = 1{\cdot}66$

⑦ ${}_{\text{water}}n_{\text{glass}} = 1{\cdot}1(2)$

$= \frac{\text{Velocity of light in water}}{\text{Velocity of light in glass}}$

Diamond is the most optically dense transparent solid: light suffers its greatest velocity reduction.

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