Transparent objects: Snell's law and Schlick's Approximation

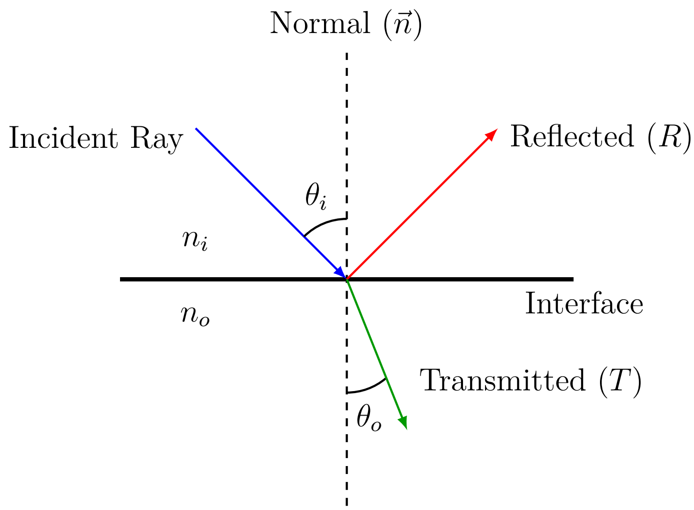

Figure 1: Interaction of light at an interface of a transparent object.

1 Snell's Law and Refraction

The direction of the transmitted ray is determined by the indices of refraction (n) of the two media. Common values for n include:

- **Vacuum**: $n = 1$
- **Air**: $n \approx 1$
- **Water**: $n \approx 1.33$
- **Glass**: $n \approx 1.46$
- **Diamond**: $n \approx 2.42$

Snell's Law relates the angles of incidence (θ_i) and refraction (θ_o):

$$n_i \sin\theta_i = n_o \sin\theta_o \tag{1}$$

When θ_o does not exist as a real number (such as when $n_i = 1.5$, $n_o = 1$, and $\sin\theta_i = 0.9$), we have complete internal reflection, and the surface behaves as a perfect mirror.

2 Schlick's Approximation

The Fresnel equations describe the reflection and transmission of light at an interface. It depends on the polarization of light, so it is not very helpful to us. Schlick's approximation provides a computationally efficient model for this effect. The reflection coefficient for light hitting a surface at a 0° angle (normal incidence) is defined by the refractive indices n_i and n_o:

$$R_0 = \left(\frac{n_i - n_o}{n_i + n_o}\right)^2 \tag{2}$$

The reflectance R for a given incident angle $\theta = \max(\theta_i, \theta_o)$ is approximated as:

$$R = R_0 + (1 - R_0)(1 - \cos\theta)^5 \tag{3}$$

3 Color Blending and Light Transport

The final color C is determined by the surface opacity and the distribution of reflected and transmitted light. The total color calculation balances the object's opacity with the Fresnel-weighted reflection and transmission:

$$C = \alpha C_o + (1 - \alpha)(R \cdot C_r + (1 - R)C_t) \tag{4}$$

- α = opacity
- C_o: Object (intrinsic) color
- C_r: Reflected color
- C_t: Transmitted color