6. Eclipse Phenomena in Radio Astronomy

6.1. Introduction

A new field in astronomy — radioastronomy — was created by the introduction of radio waves in the observational technique. Naturally we meet here with numerous analogies of the optical phenomena including the eclipses and occultations of radio sources. In these phenomena the optical refraction is replaced by the electronic refraction whose existence is conditioned by the ionised medium, for instance, the ionosphere. The radio waves traversing such a medium, i.e. the mixture: ions + free electrons + neutral particles, will be refracted according to the law of refraction with the refraction index

\[ \mu^2 = 1 - \frac{N e^2}{\pi m f^2} \]  

(6.1)

where

- \( N \) the number of particles per cm\(^3\)
- \( e \) their electrical charge and
- \( m \) their mass
- \( f \) the frequency of radio waves.

Due to the small mass of electrons, their refraction influence prevails over that of heavier ions. As \( \mu < 1 \) the sense of the electronic refraction is opposite to the optical refraction (Fig. 6.1).

Fig. 6.1. Comparison of the optical and electronic refraction
The high sensitivity of electronic refraction to the presence of electrical particles should be noted. If we have, for instance, air of density $10^{-6}$, its refraction index in the optical region will be nearly equal to unity $\mu = 1.0000000003$ and the medium behaves almost as empty space. If the same medium is only slightly ionised, i.e. every 100000th molecule having lost its electron, the refraction index for the frequency $f = 100$ MHz currently used in radio astronomy will be according to Eq. (6.1) 0.46, which is very different from unity, and producing therefore, a noticeable refraction.

In other words the electronic refraction is a very sensitive criterion of the presence of a highly rarefied atmosphere which happens to be ionised precisely because of its small density which prohibits the recombination and facilitates the penetration of exterior ionising agents.

### 6.2. Occultation Scene

The eclipse or occultation scene is represented in its most frequent form in Fig. 6.2. The plane I of the radio source is here at infinity. The

![Fig. 6.2. Scene of the radio occultation](image)

The grazing ray $A V N$ traverses the ionosphere at the minimum distance from the center

$$\rho = \frac{a + h_0}{a}$$

(6.2)

and the minimum distance of its asymptote will be

$$\rho' = \mu_0 \rho.$$ 

(6.3)