6.2 HUYGENS-FRESNEL PRINCIPLE

In order to understand how waves travel through different media, the Dutch physicist **Christiaan Huygens** enunciated a principle in 1690. The **Huygens' principle** states that every point on a primary wavefront serves as a point source for spherical secondary wavelets of the same frequency and speed as the original primary wave such that the **primary wavefront** at a later time is the envelop of these **secondary spherical wavelets**. In Fig. 6.3, I have illustrated Huygens' principle by evolution of a primary wavefront, or simply a wavefront.

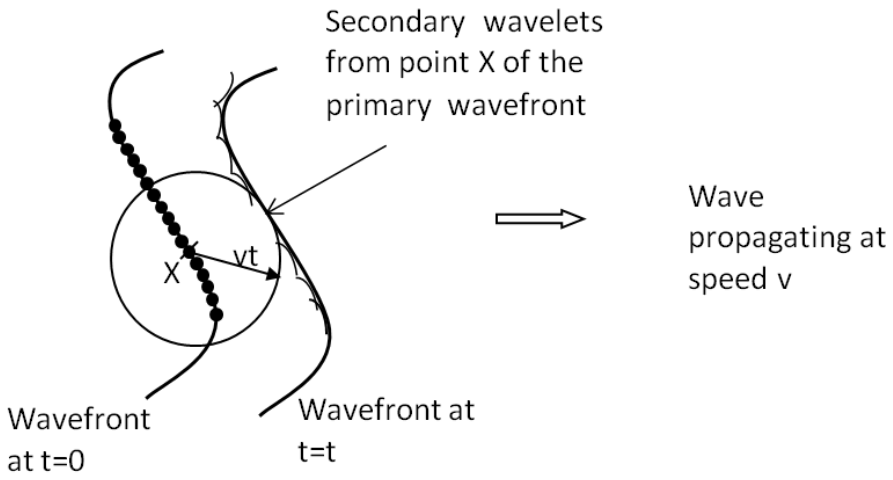

Figure 6.3: Traveling of waves according to Huygens secondary spherical wavelets.

Huygens's principle suffers from several drawbacks. It does not tell us what to do with the backward traveling part of the secondary spherical wavelet. Furthermore, it makes use of only the envelop of the secondary wavelets, and does not tell us what to do with the rest of the wavelet. More importantly, it gives rise to the same wavefront regardless of the value of the wavelength. Thus, if we follow the prescription outlined above for waves of two different wavelengths, we will get exactly the same result. But we know from experiments that different diffraction patterns result for the same aperture depending on the wavelength.

Augustin Jean Fresnel used the ideas of interference to modify the Huygens's principle so that one can understand the diffraction phenomena better. Fresnel hypothesized that every point of a primary wave could be thought of as producing secondary wavelet whose overlap and interference formed the primary wave at an instant later. The modified version is called the **Huygens-Fresnel principle**. The

main difference comes from the introduction of interference in Fresnel's modification in place of the envelop that determines the primary wave later. We will now apply the Huygens-Fresnel principle to simple cases of diffraction from single-slit, double-slit, circular aperture and diffraction grating to gain qualitative and quantitative understanding of the phenomena.