Negative refraction of a surface plasmon polariton

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We consider a system that consists of vacuum in the region $x_3 > 0$, a metal characterized by a real dielectric function $\epsilon_1(\omega)$ in the region $x_3 < 0$, $x_1 < \zeta(x_2)$, and a metal characterized by a real dielectric function $\epsilon_2(\omega)$ in the region $x_3 < 0$, $x_1 > \zeta(x_2)$. The interface profile function $\zeta(x_2)$ is a single-valued, periodic function of x_2, with a period a, that is differentiable. The vacuum metal interfaces for $x_1 < \zeta(x_2)$ and $x_1 > \zeta(x_2)$ both support a surface plasmon polariton of frequency ω. A surface plasmon polariton beam of $1/e$ half width w of this frequency is incident on the interface $x_1 = \zeta(x_2)$ from the region $x_1 < \zeta(x_2)$. Its angle of incidence measured counterclockwise from the negative x_1 axis is θ_0. In the simplest version of this theory the period of the function $\zeta(x_2)$ is chosen such that the only propagating Bragg beams of the surface plasmon polaritons transmitted into the region $x_1 > \zeta(x_2)$ are the $(0)-$ and $(-1)-$order beams, independent of the form of $\zeta(x_2)$ within a period. However, by a suitable choice for the form of $\zeta(x_2)$ the amplitude of the $(0)-$order beam can be made to vanish. The surface plasmon polariton then undergoes negative refraction. The calculation of the amplitudes of the transmitted surface plasmon polariton Bragg beams is carried out on the basis of an impedance boundary condition satisfied on the interface $x_3 = 0$. The singular integral equations to which this approach gives rise are solved by means of the Wiener-Hopf method. The negative refraction of a surface plasmon polariton obtained by this approach is not based on the use of a metamaterial with a negative index of refraction, but arises purely from the geometry of the structure assumed.