fulfilled, which is also the condition for validity of the independent-groove model, $r_{array} \approx r$ and $\alpha_{array} \approx \sum_n \alpha(a_n)$.

In the CMM formalism, $F_{array} = 1 + I_G/I_0$, so Eq. (11) recovers the phenomenological model given by Eq. (1). Moreover, in Fig. 8 we show $|\alpha_{array}|$ as a function of a_1 for the same geometrical parameters considered in Fig. 2 at $\lambda_R = 630$nm. Notably, we find for large a_1 values that $|\alpha_{array}|$ behaves as $a_1^{0.45} \sim \sqrt{a_1}$, as predicted by the simple phenomenological model. Note also that, despite the slow dependance of α_{array} with a_1, the reillumination at the centre of the hole strongly oscillates with a_1, due to the exponential terms in Eq. (11). Additionally, inset in Fig. 8 shows that $|r_{array}|$ hardly depends on a_1, as it was expected from Fig. 7.

4. Conclusions

We have analyzed the optical transmission in bull's eye structures as a function of the distance between the central hole and its nearest groove, a_1, in the case when all groove depths and widths are subwavelength. We have shown that the transmittance presents maxima for given values of a_1 and wavelength, which are due to constructive interference of the light reemitted by grooves (which in that case behave almost independently) into the central hole. This reemitted light is in the form of surface plasmons. Furthermore, each groove acts as two connected cavities and, for fully explaining the transmittance spectra, the reflection by one cavity of the surface plasmon radiated by the other cavity must be taken into account. We have shown that the amplitude for coupling of incident radiation into a groove increases with groove radius, while the reflection coefficient of a groove for surface plasmons does not. These ingredients have been combined to give a simple Huygens-Fresnel view of the total coupling and reflection of light by the groove array. Finally, our results show that there is not a direct correspondence between field enhancement at the surface and transmission enhancement, as there are resonances in the groove array that do not lead to strong re-illumination at the central hole.

Acknowledgments

We acknowledge the support from the Spanish Ministry of Science and Innovation (the projects MAT2008-06609-C02 and CSD2007-046-Nanolight.es) and the support from the ERC (Grant 227557).

#142697- $15.00USD Received 14 Feb 2011; revised 24 Mar 2011; accepted 28 Mar 2011; published 12 May 2011