Not seeing the light [DOI: 10.1051/epn:2007016]

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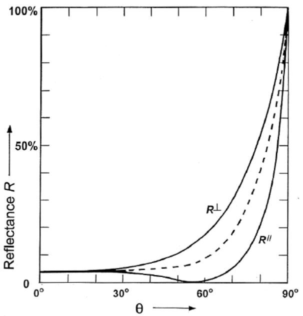
Back in 1808 the young French soldier Etienne Louis Malus noted that there is something funny about reflections. While looking through a crystal of Iceland spar calcite in his Paris apartment, he noticed variations in the sunlight reflected from windows in the *Palais du Luxembourg* across the street when he rotated the crystal. This observation, often considered as the discovery of light polarization, laid the basis for our Polaroid glasses. Indeed, the most common use of Polaroid glasses is aimed at reducing annoying reflections.

To fully appreciate the issue, let us recall the behaviour of light when reflected from glass, or from water. The reflectance as a function of incident angle θ (the angle to the normal) is given here for convenience. The graph is for the case of glass, but is only marginally different in the water case. It shows the reflectance for the two polarizations parallel and perpendicular with respect to the plane of incidence. The dashed curve is the average, or the effective reflectance for non-polarized light.



Before entering into a discussion of the two different polarizations, it is interesting to notice that for grazing incidence (θ = 90°) the reflectance becomes unity. Therefore, the image of the setting sun above a quiet lake appears just as bright as the sun itself, for example.

At the other end of the axis, for light incident along the surface normal, the reflectance is a few percent only: for glass having a refractive index n = 3/2 we find $(n-1)^2 / (n+1)^2 = (1/5)^2$ or 4%. For water with n = 4/3 we find even less: $(1/7)^2$ or 2 % only. Therefore, if we look straight into a pond, the reflection of our own face is really weak, and there is a fair chance that we can see the fish, provided that it is there and that the water is clear.

But we can do better than that by going to angles in between these two extremes and using Polaroid glasses. Obviously, our best choice is Brewster's angle, where one of the two polarizations has zero reflectance, such that the reflected light is completely polarized. It is the angle whose tangent is the index of refraction: θ = 56° for glass and 53° for water. Here our Polaroid glasses work perfectly.

So, if we want to make a picture of something behind glass, Brewster comes to our rescue, provided that we orient our Polaroid filter correctly. And, in the case of the pond: using Polaroid glasses we can completely get rid of the reflection of the sky. Use a bit of physics, and outsmart the fish.