8. Optics experiment (10 p)

Equipment: a cylindrical bottle filled with water and having a millimetre scale across half of its perimeter (seen when looking through the bottle); measuring tape.

1) Determine, how long arc of the bottle's measuring scale could be seen simultaneously if looking at it through the bottle from a very distant point (much larger than the bottle's diameter), assuming that the observation point lies at the height of the millimetre scale.

2) Using the results of the previous experiment determine the angular radius of a rainbow (the angle between a ray coming to the observer's eye from a rainbow, and the axis of the cone formed by other such rays).

Remark: Rainbow is formed due to those rays which enter a spherical water droplet, reflect once from its surface internally, and exit the droplet after second refraction. Note that the internal reflection is only partial, and not total, see figure. The exit angle α has a maximum as a function of the impact parameter b; the angular radius of the rainbow equals to the maximal exit angle [indeed, if light of intensity I_0 falls onto the droplet with all possible impact parameters $b < r$, the light energy per impact parameter range Δb is $2I_0\pi b\Delta b$; hence, the energy per exit angle interval $\Delta\alpha$ is $\Delta I/\Delta\alpha = 2I_0\pi b\Delta b//\Delta\alpha = 2I_0\pi b\,(d\alpha/db)^{-1}$, which diverges near the maximum of the function $\alpha(b)$.]

