石英晶体+MgF2晶体消色差波片理论计算

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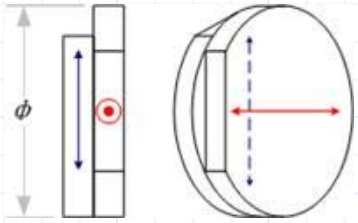
零级消色差波片是通过将多级石英晶体波片的快轴与氟化镁波片的慢轴对准，使两块波片的快慢轴光程差在一个较宽光谱范围内为λ/4或λ/2。石英晶体和氟化镁或紫外蓝宝石可最大程度地降低位相延迟对波长的依赖关系，这样在消色差波片的工作范围内可得到平坦光谱响应,其装配图如下:



针对石英晶体+MgF2晶体结构消色差波片做分件参数的理论计算如下:

石英晶体折射率:

$$n_o1(\lambda) := \sqrt{2.35734 - 0.0116801\left(\frac{\lambda}{10^3}\right)^2 + \frac{0.0105792}{\left(\frac{\lambda}{10^3}\right)^2} + \frac{0.000105436}{\left(\frac{\lambda}{10^3}\right)^4} + \frac{0.00000324285}{\left(\frac{\lambda}{10^3}\right)^6} + \frac{0.0000000669}{\left(\frac{\lambda}{10^3}\right)^8}}$$

$$n_e1(\lambda) := \sqrt{2.38448 - 0.0122288\left(\frac{\lambda}{10^3}\right)^2 + \frac{0.011002}{\left(\frac{\lambda}{10^3}\right)^2} + \frac{0.000111501}{\left(\frac{\lambda}{10^3}\right)^4} + \frac{0.00000316816}{\left(\frac{\lambda}{10^3}\right)^6} + \frac{0.000000047822}{\left(\frac{\lambda}{10^3}\right)^8}}$$

MgF2晶体折射率:

$$n_o2(\lambda) := \sqrt{1 + \frac{0.48755108\cdot\left(\frac{\lambda}{10^3}\right)^2}{\left(\frac{\lambda}{10^3}\right)^2 - 0.04338408^2} + \frac{0.39875031\cdot\left(\frac{\lambda}{10^3}\right)^2}{\left(\frac{\lambda}{10^3}\right)^2 - 0.09461442^2} + \frac{2.3120353\cdot\left(\frac{\lambda}{10^3}\right)^2}{\left(\frac{\lambda}{10^3}\right)^2 - 23.793604^2}}$$

$$n_e2(\lambda) := \sqrt{1 + \frac{0.41344023\cdot\left(\frac{\lambda}{10^3}\right)^2}{\left(\frac{\lambda}{10^3}\right)^2 - 0.03684262^2} + \frac{0.50497499\cdot\left(\frac{\lambda}{10^3}\right)^2}{\left(\frac{\lambda}{10^3}\right)^2 - 0.09076162^2} + \frac{2.4904862\cdot\left(\frac{\lambda}{10^3}\right)^2}{\left(\frac{\lambda}{10^3}\right)^2 - 23.771995^2}}$$

消色差波片设计波长及延迟度:　　$\lambda1 := 428.7$　　$\lambda2 := 688$　　$\Delta := \frac{1}{2}\pi$

单个晶体波片的延迟度可以表示为:

$$\delta1(d1,\lambda) := \frac{2\cdot\pi\cdot(n_o1(\lambda) - n_e1(\lambda))\cdot d1}{\lambda}$$

$$\delta2(d2,\lambda) := \frac{2\cdot\pi\cdot(n_o2(\lambda) - n_e2(\lambda))\cdot d2}{\lambda}$$

则在两个设计参考波长处累加延迟度可以表示为:

$$\delta_{\lambda 1}(d1,d2) := \delta 1(d1,\lambda 1) + \delta 2(d2,\lambda 1)$$

$$\delta_{\lambda 2}(d1,d2) := \delta 1(d1,\lambda 2) + \delta 2(d2,\lambda 2)$$

估值

$$d1 := 100000$$

$$d2 := 100000$$

约束

$$\frac{2\cdot\pi\cdot\left(n_o1(\lambda 1)-n_e1(\lambda 1)\right)\cdot d1}{\lambda 1} - \frac{2\cdot\pi\cdot\left(n_o2(\lambda 1)-n_e2(\lambda 1)\right)\cdot d2}{\lambda 1} = \Delta$$

$$\frac{2\cdot\pi\cdot\left(n_o1(\lambda 2)-n_e1(\lambda 2)\right)\cdot d1}{\lambda 2} - \frac{2\cdot\pi\cdot\left(n_o2(\lambda 2)-n_e2(\lambda 2)\right)\cdot d2}{\lambda 2} = \Delta$$

求解器

$$res := \mathrm{find}(d1,d2) = \begin{bmatrix} 2.706\cdot 10^5 \\ 2.219\cdot 10^5 \end{bmatrix}$$

根据以上求解模块可以获得满足设计要求的石英晶体厚度d1与MgF2晶体厚度d2:

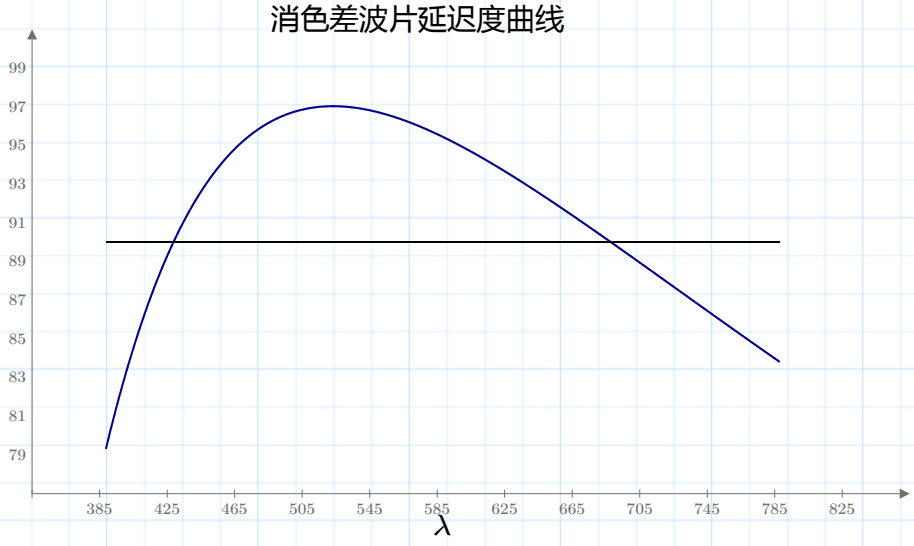
$$d1 := res(0,0) \qquad d2 := res(1,0)$$

将以上值带入如下消色差波片延迟度计算公式:

$$\delta(\lambda) := \frac{2\cdot\pi\cdot\left(n_o1(\lambda)-n_e1(\lambda)\right)\cdot d1}{\lambda} - \frac{2\cdot\pi\cdot\left(n_o2(\lambda)-n_e2(\lambda)\right)\cdot d2}{\lambda}$$

$$\lambda := \lambda 1 - 40, \lambda 1 - 40 + 0.1 .. \lambda 2 + 100$$

消色差波片延迟度曲线



$$\frac{\delta(\lambda)\ (deg)}{\Delta\cdot\frac{180}{\pi}}$$

以上计算方法用于石英晶体与MgF2晶体消色差波片已知波长与延迟度求解分件厚度.