light. From these two planes, we can derive the relationship of the WGM polarization angle ψ of the ordinary ray polarization direction as a function of the crystal cut angle γ and resonator position β: $\tan(\psi) = \tan(\gamma)\sin(\beta)$. The theoretically calculated WGM polarization angle ψ for the ordinary ray polarization in the resonator is plotted in Fig. 4 together with the measured optimal coupling angle $2\theta_0$ of the incident light. The measured polarization angle $2\theta_0$ follows the change of the ordinary ray polarization direction in the crystal resonator around the circumference in a similar functional dependence: it is horizontally polarized at $\beta = 0°$ or 180° when the optic axis is in the plane parallel to the prism coupling surface; and it reaches a maximum angle when the optical axis is in the plane perpendicular to the prism coupling surface.

The exact transformation from a linear polarization of the incident light to the polarization inside the resonator is not trivial. Experimentally we observed a coupling behavior of linearly polarized light following Malus's law at all coupling positions β. Thus, it is justified to assume linear polarization inside the disk. We can then write $\tan(\psi) = c\,\tan(2\theta_0)$, where c is a constant coefficient describing the linear polarization change from the input polarization to the WGM polarization. The function fits well the measured $2\theta_{0,}$ yielding $c = 0.54$, as shown in Fig. 4.

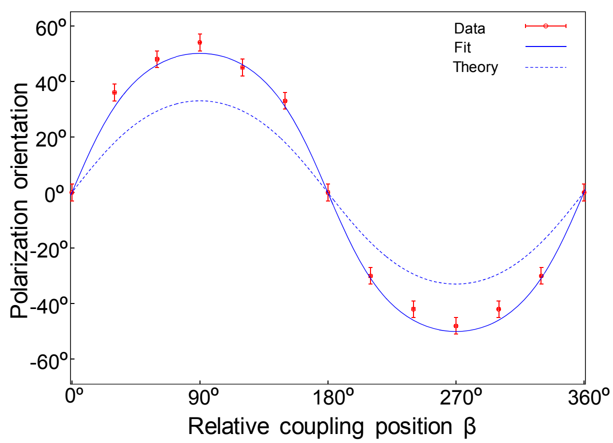

Fig. 4. Polarization orientation along the WGM disk circumference: measured optimal coupling angle of the incident light (data points), computed polarization orientation of the ordinary ray inside the resonator (dashed lines), and the fit of the transformed input polarization inside the resonator (solid lines).

In contrast with z-cut cases, we have not been able to find the second, orthogonally polarized family of WGMs in the angle-cut BBO resonators. We attribute this to the inhibited reflection phenomenon [15]. It is well known that when an ordinary or extraordinary polarized beam impinges on the inner surface of a birefringent crystal, each reflection in general produces two rays, again ordinary and extraordinary polarized. For nearly-grazing incidence at the inner surface of negative crystals, the ordinary-to-extraordinary reflection may be inhibited, and the energy is then redistributed to the ordinary polarization [15]. Though the polarization state of light in a WGM resonator is more complicated and may not be completely treated using the ray theory, the double reflection and inhibited reflection mechanism may be responsible for the lack of the second polarization mode and for the polarization rotation discussed above. A quantitative analysis of this phenomenon is out of the scope of this report and will be a subject of further investigation.

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6. Conclusion

In conclusion, we have fabricated for the first time a WGM resonator from BBO crystals. We demonstrated the first ultra-high *Q* WGMs in the UV wavelength range and in an angle-cut resonator made of a strongly birefringent crystal. New upper bounds of the material absorption coefficients of BBO at three different wavelengths are established. Furthermore, polarization properties of WGMs in an angle-cut BBO resonator have been experimentally investigated. There exists only one polarization mode of ordinary ray in the angle-cut BBO resonators and its polarization precession is observed. This work lays a foundation for further investigation of WGM properties of non-z cut birefringent resonators and their role as sensor and nonlinear optics applications.

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