Interferometer for phase-stabilization of quantum nodes using SIL-based color centers

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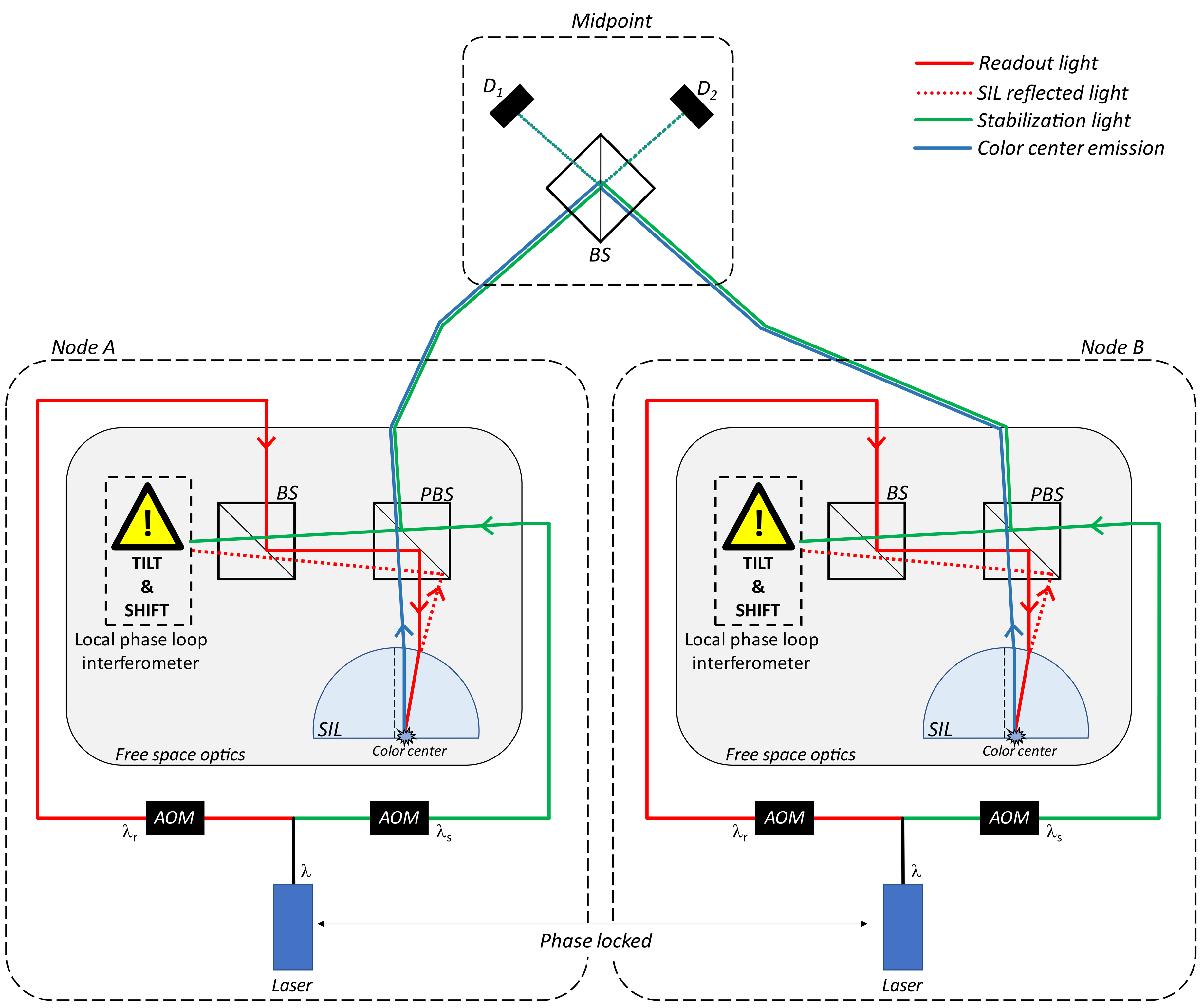
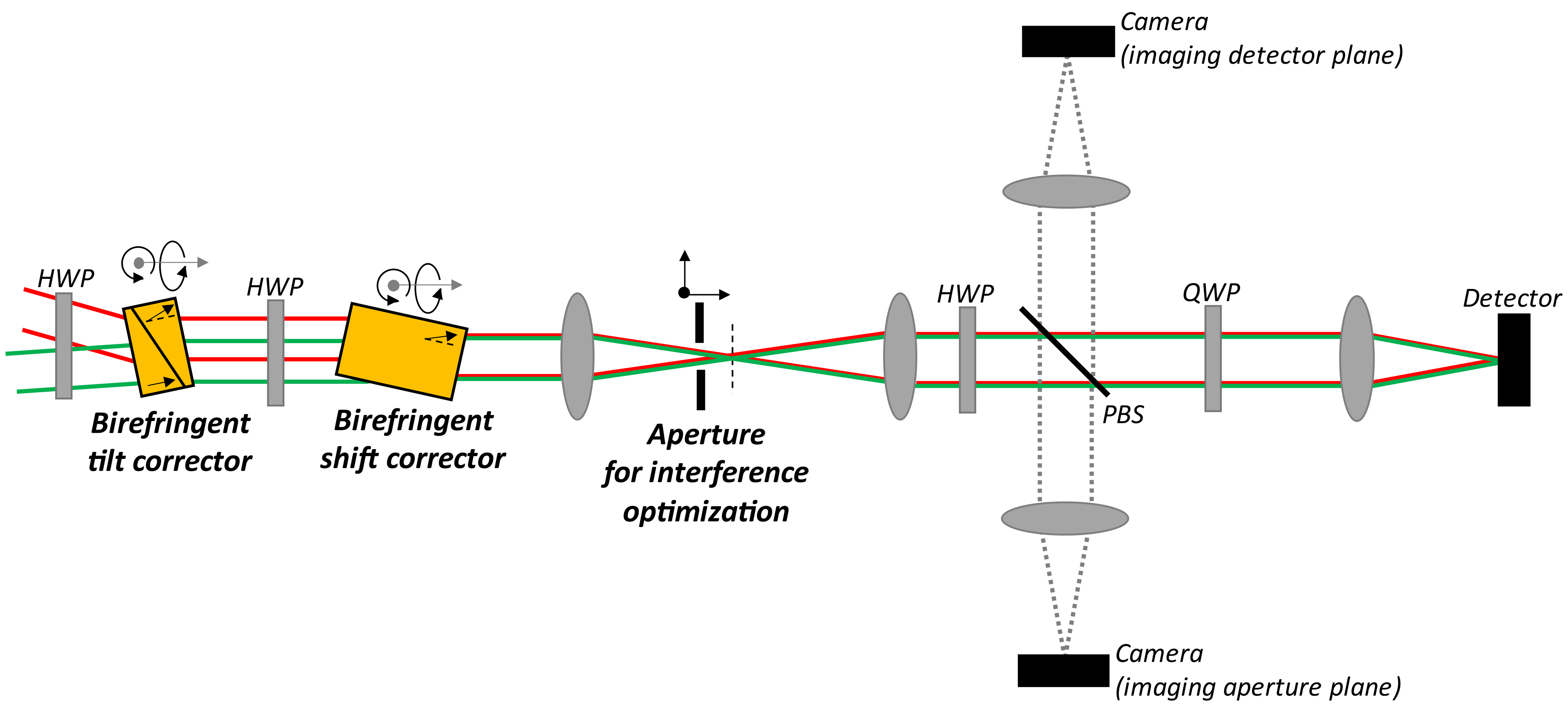
Interferometer for phase-stabilization of quantum nodes using SIL-based color centers



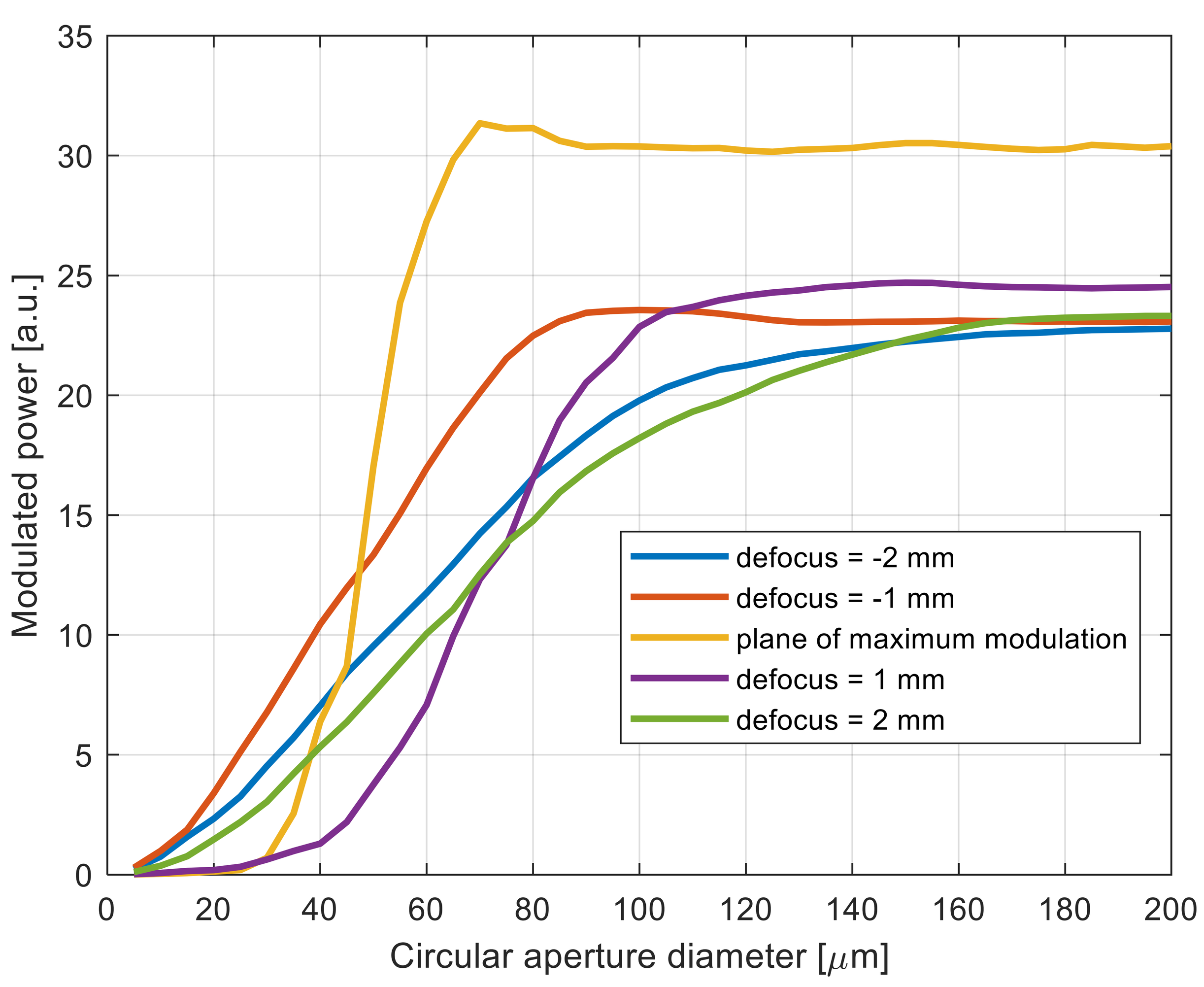
Highly simplified layout, illustrating the practically unavoidable tilt and shift between the two beams entering the local interferometer

***Challenge*:**
Many quantum entanglement generation protocols require phase stabilization between the nodes. For color centers that are embedded in a solid immersion lens (SIL) often a reflection from the SIL's surface is input to an interferometer where it is mixed with a reference beam (stabilization light). However, the SIL reflected beam does not travel colinear with the photons that are emitted by the color center, which ultimately leads to a reduction of the interferometer's signal-to-noise ratio. Additionally, imperfections of the SIL-surface introduce aberrations into the reflected light, thereby further reducing the signal-to-noise ratio.

***Solution*: Since the SIL reflected light and the stabilization light are orthogonally polarized upon entering the interferometer, we use specially designed birefringent crystals to correct for the relative tilt and shift. Each birefringent crystal can be individually rotated around two axes that allow to adjust the direction and magnitude of the tilt and shift.**



Schematic optical layout of an interferometer that uses birefringent crystals to ensure beam overlap, and an aperture to optimize modulated power onto the detector



Simulated modulated power onto the detector for different apertures at various positions around the beam waist (based on through focus camera images)

In order to mitigate the impact of aberrations on the interference contrast, an aperture can be positioned in or around the beam waist of an intermediate focus. The beam waist volume can be imaged using a camera. By adjusting the AOM frequencies such that an optical beat within the framerate of the camera is generated, timeseries of images can be analyzed to determine the spatial regions of the overlapping wavefronts that contribute positively to the overall modulation. This allows to optimize the shape and position of the aperture.

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