

more, because of this large detuning, we can ignore Doppler broadening and approximate the Voigt profile of the resonance (obtained via convolution of the Gaussian profile due to Doppler broadening and the Lorentzian profile due to collisional and natural broadening) as a Lorentzian [21]. Thus, we can describe the atomic susceptibility $\chi_{full}(\omega)$ experienced by a weak optical field as it propagates through a vapor cell containing Rubidium vapor as a sum of Lorentzian functions weighted appropriately by the various transition strengths (see Eq. (8) in Ref. [3]). Because we work so far from the atomic resonances, the details of the underlying hyperfine structure are not important. This allows us to reduce the full model of the atomic susceptibility to an effective double-Lorentzian susceptibility for the D1 and D2 lines given as

$$\chi_{eff}(\omega) = -N(T) \left(\frac{s_1}{\omega - \omega_1 + i\gamma_1} + \frac{s_2}{\omega - \omega_2 + i\gamma_2} \right), \quad (1)$$

where $s_1 = 2.25 \times 10^{-13}$ and $s_2 = 4.58 \times 10^{-13}$ m³rad/s are effective transition strengths, ω_1 and ω_2 are the effective resonance frequencies, and γ_1 and γ_2 are the effective linewidths (including both natural and collisional broadening) for the D1 and D2 transitions, respectively [22]. We model the temperature-dependent atomic density $N(T)$ via the vapor pressure relations given in Ref. [23] by treating the Rubidium vapor as an ideal gas. For the range of parameters considered in the remainder of the paper, the normalized deviation between χ_{full} and χ_{eff} (defined as $|(\chi_{full} - \chi_{eff})/(\chi_{full} + \chi_{eff})|$) is less than 5×10^{-3} , thus making their predictions nearly indistinguishable.

The complex index of refraction is related to the susceptibility as $n = n' + in'' \approx 1 + \chi_{eff}/2$ (since $\chi_{eff} \ll 1$ for the regime studied here). This allows us to compute the absorptive optical depth as $\alpha L = 2\omega L n''/c$, where L is the interaction length and α is the intensity absorption coefficient. Because we assume only weak optical fields propagating through the vapor, we describe the fractional absorption of light using Beer's Law as $1 - I_{out}/I_{in} = 1 - \exp(-\alpha L)$. The group index is found through the relation $n_g(\omega') = n' + \omega dn'/d\omega|_{\omega=\omega'}$, which allows us to calculate the group delay $t_D = L(n_g - 1)/c$. We note that the group velocity dispersion, given as $GVD = d(1/v_g)/d\omega$, is zero at $\lambda_c = 788.4$ nm (at the center of gravity between the