A Bell-Bloom experiment with polarization-modulated light

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In 1961 Bell and Bloom demonstrated [1] that a circularly polarized resonant light beam traversing mercury vapour exposed to a static transverse magnetic field *B* induces magnetic resonance transitions when the light power is modulated at the atomic Larmor frequency ω_L. The magnetic resonance manifested itself as a Lorentzian-shaped response in the transmitted light power, with a maximum when the modulation frequency ω_{mod} matches ω_L. Similar resonances can be observed when modulating either the light frequency or polarization. Recently, a theoretical model was proposed that describes the features of the resonance spectra induced by amplitude-, frequency-, or polarization-modulated light [2]. Here we report on a study of polarization modulation experiments on the 4-3 hyperfine component of the D_1 transition in Cs vapour contained in a paraffin-coated cell. The laser beam's polarization was switched between σ_+ and σ_- at $\omega_{mod} = 2\pi$ 200 Hz. We recorded variations of the transmitted light power *P* when scanning the transverse magnetic field amplitude *B* ($\propto \omega_L$). The $P(\omega_L)$ spectra show resonances at fields corresponding to Larmor frequencies obeying $\omega_L = m\,\omega_{mod}$. We observed magnetic resonance lines up to *m*=21, and studied the resonance amplitudes for *m*=0…+5 with square-wave modulations of various duty cycles η. For η=0.5 we found only resonances at odd harmonics, while for $\eta \neq 0.5$ we observed resonances at even and odd harmonics. The dependence of the relative resonance amplitudes $A_{m,\eta}$ on *m* and η is in excellent agreement (Fig. 1) with algebraic expressions of [2] predicting

$$A_{m=0,\eta} \propto (2\eta-1)^2 \quad \text{and} \quad A_{m\neq 0,\eta} \propto \frac{4}{\pi^2}\frac{\sin^2(m\pi\eta)}{m^2}. \qquad (1)$$

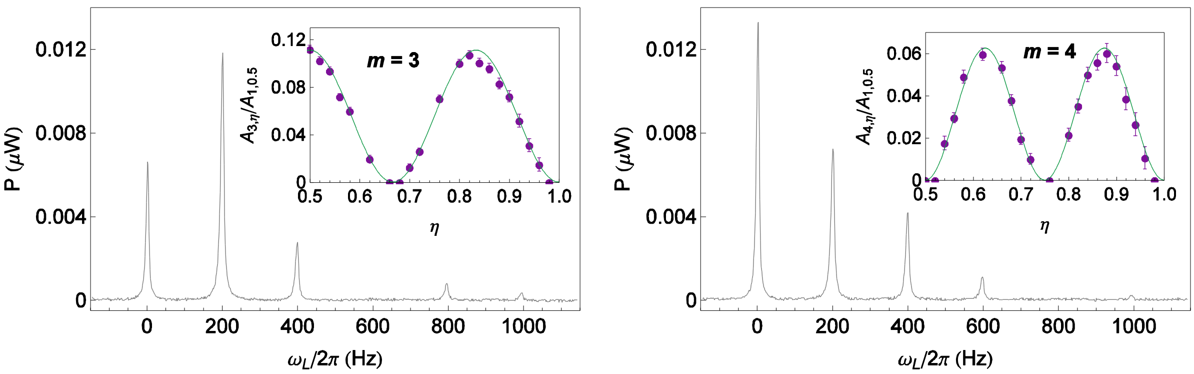

Figure 1: Typical resonance spectra for η=0.66 (left) and η=0.76 (right). Insets: Dependence of relative amplitudes of the *m* = 3 and *m* = 4 resonances on the duty cycle η, together with model predictions (solid lines).

References:
[1] W. E. Bell and A. L. Bloom, Phys. Rev. Lett. **6**, 280 (1961).
[2] Z. D. Grujić and A. Weis, submitted to Phys. Rev. A (2013).