Abstract Submitted
for the DAMOP15 Meeting of
The American Physical Society

Excess optical quantum noise in atomic sensors[1] IRINA NOVIKOVA, EUGENIY MIKHAILOV, College of William & Mary, YANHONG XIAO, Fudan University — Enhanced nonlinear optical response of a coherent atomic medium is the basis for many atomic sensors, and their performance is ultimately limited by the quantum fluctuations of the optical read-out. Here we demonstrate that off-resonant interactions can significantly modify the quantum noise of the optical field, even when their effect on the mean signal is negligible. We illustrate this concept by using an atomic magnetometer based on the nonlinear Faraday effect: the rotation of the light polarization is mainly determined by the resonant light-induced spin alignment, which alone does not change the photon statistics of the optical probe. Yet, we found that the minimum noise of output polarization rotation measurements is above the expected shot noise limit. This excess quantum noise is due to off-resonant coupling and grows with atomic density. We also show that the detection scheme can be modified to reduce the measured quantum noise (even below the shot-noise limit) but only at the expense of the reduced rotational sensitivity. These results show the existence of previously unnoticed factors in fundamental limitations in atomic magnetometry and could have impacts in many other atom-light based precision measurements.

[1]We acknowledge the support from AFOSR (grant FA9550-13-1-0098), NSF (grant PHY-1308281), NBRPC(973 Program Grant 2012CB921604 and 2011CB921604), and NNSFC (Grants No. 11322436)

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Date submitted: 30 Jan 2015 Electronic form version 1.4