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**Continuous monitoring of a quantum state beyond classical limits**[1] GIORGIO COLANGELO, FERRAN MARTIN CIURANA, ROBERT J SEWELL, MORGAN W MITCHELL[2], ICFO - The Institute of Photonic Sciences, QUANTUM INFORMATION WITH COLD ATOMS AND NON-CLASSICAL LIGHT TEAM — Continuous monitoring of a quantum system is essential to high-sensitivity measurement of time-varying quantities. Precession of a spin ensemble may be monitored by measuring spin projectors $F_\alpha$ at different times. Since these projectors do not commute, quantum measurement back-action (QMBA) necessarily enters the measurement record, introducing errors and limiting sensitivity. Here we show how to reduce this disturbance below $\delta F_\alpha \sim \sqrt{N}$, the classical limit for $N$ spins, by directing the QMBA almost entirely into an unmeasured spin component. This generates a **planar squeezed state** which allows simultaneous precise knowledge of spin angle and amplitude. We demonstrate continuous monitoring of a precessing spin ensemble with steady-state angular sensitivity 2.9 dB beyond the standard quantum limit, simultaneous with amplitude sensitivity 7.0 dB beyond Poisson statistics, surpassing classical limits in non-commuting observables for the first time. Our method is close to practical application in high-performance atomic sensors, such as magnetometers and clocks, and is compatible with multi-pass and cavity build-up methods.

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