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The ground state of a spin-1 anti-ferromagnetic atomic condensate for Heisenberg limited metrology LING-NA WU, State Key Laboratory of Low Dimensional Quantum Physics, Department of Physics, Tsinghua University, LI YOU, State Key Laboratory of Low Dimensional Quantum Physics, Department of Physics, Tsinghua University; Collaborative Innovation Center of Quantum Matter — The ground state of a spin-1 atomic condensate with anti-ferromagnetic interaction can be applied to quantum metrology approaching the Heisenberg limit. Unlike a ferromagnetic condensate state where individual atomic spins are aligned in the same direction, atoms in an anti-ferromagnetic ground state condensate exist as spin singlet pairs, whose inherent correlation promises metrological precisions beyond the standard quantum limit (SQL) for uncorrelated atoms. The degree of improvement over the SQL is measured by quantum Fisher information (QFI), whose dependence on the ratio of linear Zeeman shift p to spin-dependent atomic interaction c is studied. At a typical value of $p = 0.4c$ corresponding to a magnetic field of 28.6 μG with $c = h \times 50\,\mathrm{Hz}$ (for ^{23}Na atom condensate in the $F = 1$ state at a typical density of $\sim 10^{14}\mathrm{cm}^{-3}$), the scaled QFI can reach $\sim 0.48N$, which is close to the limits of N for NooN state, or $0.5N$ for twin-Fock state. We hope our work will stimulate experimental efforts towards reaching the anti-ferromagnetic condensate ground state at extremely low magnetic fields.

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