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Coherent Population Trapping Based Collective State Atomic Clock Using Trapped Atoms MAY E. KIM, RENPENG FANG, RESHAM SARKAR, SELIM M. SHAHRIAR, Northwestern University — In most atomic clocks, the signal collection efficiency is limited to only a few percent due to unavoidable geometric constraints, which limits its stability. We describe a coherent population trapping (CPT) based atomic clock that can achieve a much higher collection efficiency, and has reduction in linewidth by factor of $\sqrt{N}$, where N is number of atoms. The CPT process pumps atoms into dark state, $|-\rangle$, which is a superposition of two atomic states. When all atoms are in $|-\rangle$, the system is in collective state $|E_D\rangle = |-,-,-,...-\rangle$. The signal corresponding to measurement of $|E_D\rangle$ has resonance that is narrowed by $\sqrt{N}$ compared to the width in conventional CPT clock. This narrowing results from interference among collective states, and can be interpreted as manifestation of effective increase in clock frequency by $\sqrt{N}$. The amplitude of $|E_D\rangle$ can be observed via null measurement of bright state $|+\rangle$. When no fluorescence from $|+\rangle$ is detected, the system is in $|E_D\rangle$. By coherent Raman scattering of anti-Stokes photons in an optically dense cloud of cold atoms, the collection efficiency approaches unity, which improves clock stability significantly, leading to advance in precision time keeping.

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