Wei *et al.* Reply: In the preceding comment [1] on our work about the quantum phase of an induced dipole in a magnetic field [2], Hagen applied the cononical formalism to the Lagrangian

$$\mathcal{L} = \frac{1}{2}M\mathbf{v}^2 + \frac{1}{2}\alpha(\mathbf{E} + \mathbf{v} \times \mathbf{B})^2, \tag{1}$$

to get the relevant Hamiltonian

$$\mathcal{H} = \frac{1}{2}(M + \alpha B^2)^{-1}(\mathbf{p} + \alpha\mathbf{E} \times \mathbf{B})^2 - \frac{1}{2}\alpha\mathbf{E}^2. \tag{2}$$

He then pointed out the fact that the radial wave function

$$\left[\frac{1}{r}\frac{\partial}{\partial r} r \frac{2(M + \alpha B^2)\mathcal{E}}{\hbar^2} - \frac{m^2 + 2m\alpha kB/\hbar - M\alpha k^2/\hbar^2}{r^2}\right] f_m(r) = 0 \tag{3}$$

does not allow quantum mechanically well-defined solutions when the numerator of the $1/r^2$ term is negative. In the case of $m = 0$ and nonvanishing electric field the numerator is indeed negative.

Based on such a fact, Hagen claimed that our proposed experiment cannot be carried out regardless of the strength of the external electric and magnetic field.

In our opinion, Hagen's argument is purely theoretical, some important practical aspects are ignored. The difficulty of a negative $1/r^2$ potential comes from the assumption of an infinitely thin charged wire. Actually, the wire has a finite radius r_0, atoms never get into the region of $r < r_0$. Further, we will show that atoms can never get too close to the wire to cause a collision. In a practical atomic beam interferometer, atoms in the two beams have a large velocity of 10^2 to 10^3 m s^{-1}, the quantum number m in Eq. (3) should be very large.

From a very simple consideration of classical mechanics, the attractive force on the atom by the charged wire is

$$|\mathrm{F}_{\mathrm{attr}}| = |\nabla(\tfrac{1}{2}\alpha\mathbf{E}^2)| \approx \alpha E^2/r\,. \tag{4}$$

The centrifugal force of an atom circling the wire with the kinetic energy Mv^2 should be

$$|\mathbf{F}_{\mathrm{cent}}| = Mv^2/r\,. \tag{5}$$

With these parameters in Ref. [2], $\alpha \approx 10^{-39}$ F m^2, $r_0 \approx$ 1 mm, $k \approx 10^4$ V, $E \approx 10^7$ V/m, we have $\alpha\mathbf{E}^2 \approx (10^{-39}\ \mathrm{F\,m^2}) \times (10^{14}\ \mathrm{V^2\,m^{-2}}) = 10^{-25}$ J, while Mv^2 is typically the thermal kinetic energy of the atoms from the oven with a temperature $T > 300$ K, $Mv^2 \approx k_BT > 10^{-21}$ J [3–5]. Therefore,

$$|\mathbf{F}_{\mathrm{cent}}| \gg |\mathbf{F}_{\mathrm{attr}}|\,.$$

The collision between the atoms and the wire is well avoided.

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