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COMMENT

Comment on 'Coulomb torque—a general theory of electrostatic forces in many-body systems'

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In a recent paper [1, 2] Khachatourian and Wistrom claim that when three (or more) metallic spheres are in proximity and at constant potential they will start spinning. The authors also claim that the effect was observed experimentally (e.g., [11] in [1]). Some authors (e.g., [3]) noted that the predicted spinning effect might violate the law of conservation of energy.

From the way the torque responsible for the alleged spinning is calculated in [1] it is clear that it acts on the free charges sitting on the surface of the metallic spheres. As a consequence if the torque is not zero at a point, a surface current would exist, which would contradict the assumption of static charges used to calculate the potential in [1]. This simple argument against spinning [3] was rejected by Wistrom [4] on the basis that '... the explicit solution to the generalized many-body electrostatic problem predicts the existence of a Coulomb torque ...'.

We show that the calculations of [1] actually indicate that the torque on each sphere is null. The starting point is equation (27); we add at its right-hand side the contribution of the free charges sitting on the surface of sphere 1 to the torque acting on sphere 1, $\vec{T}_1 = -\vec{T}_{12} - \vec{T}_{13} - \vec{T}_{11}$. This is in fact the full expression for $\vec{T}_1$ and, in addition, the new term should not change the result of equation (28)

$$\vec{T}_1 = K \int \mathrm{d}Q_1\, \mathrm{d}Q_2 \left(\vec{a}_1 \times \vec{\nabla}_{21} \frac{1}{R_{12}} \right) + K \int \mathrm{d}Q_1\, \mathrm{d}Q_3 \left(\vec{a}_1 \times \vec{\nabla}_{31} \frac{1}{R_{13}} \right) + K \int \mathrm{d}Q_1\, \mathrm{d}Q_{1'} \left(\vec{a}_1 \times \vec{\nabla}_{1'1} \frac{1}{R_{11'}} \right). \qquad (1)$$

Using equations (29)–(31) of [1] and the corrected equation (32) of [2], one obtains

$$\vec{T}_1 = -K \int \mathrm{d}Q_1\, \mathrm{d}Q_2\, \vec{L}(\theta_1, \phi_1) \frac{1}{R_{12}} - K \int \mathrm{d}Q_1\, \mathrm{d}Q_3\, \vec{L}(\theta_1, \phi_1) \frac{1}{R_{13}}$$

$$
\begin{aligned}
&- K \int \mathrm{d}Q_1\, \mathrm{d}Q_{1'}\, \vec{L}(\theta_1, \phi_1) \frac{1}{R_{11'}} \\
&= - \int \mathrm{d}Q_1\, \vec{L}(\theta_1, \phi_1) \left[K \int \mathrm{d}Q_2 \frac{1}{R_{12}} + K \int \mathrm{d}Q_3 \frac{1}{R_{13}} + K \int \mathrm{d}Q_{1'} \frac{1}{R_{11'}} \right] \\
&= - \int \mathrm{d}Q_1\, \vec{L}(\theta_1, \phi_1) V_1 \qquad (2)
\end{aligned}
$$

where the last equality was obtained from the definition of V_1 given in equation (1) of [1]. Equation (29) of [1] indicates that $\vec{L}(\theta_1, \phi_1)$ is a differential operator containing only derivatives with respect to θ_1 and ϕ_1 on the surface of sphere 1 where the potential V_1 is constant by construction. Therefore, $\vec{L}(\theta_1, \phi_1)V_1 = 0$ everywhere on the surface of sphere 1 and $\vec{T}_1 = 0$.

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