SRYAHWA PUBLICATIONS

Open Access Journal of Physics
ISSN: 2637-5826 | Volume 8, Issue 3, 2026
https://doi.org/10.22259/2637-5826.0803001

RESEARCH ARTICLE

# Can Steradians Modify Our Understanding of Quantum Mechanics and the Special Theory of Relativity?

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Received: 26 April 2026 Accepted: 11 May 2026 Published: 15 May 2026

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## Abstract

Since the birth of quantum mechanics, physicists debated whether the interior of atoms can be pictured in any meaningful way and if the composition of quantum particles can be revealed in a classical way. Planck in 1900 introduced the Planck constant with the dimension [Js]. Einstein in 1905 modified the Planck constant with the dimension [Js cycle$^{-1}$]. Nicholson (1912), Bohr (1913), and Sommerfeld (1915) introduced the combination of the Planck constant with radians as h/2π [Js radian$^{-1}$] and modelled the inner of the Rutherford atom. Heisenberg (1925), Dirac (1925), and Schrödinger (1926) were working with the Planck constant in their formulae as ih/2π [i Js radian$^{-1}$]. The founding fathers of quantum mechanics did not all hold the same interpretative position expressed as: stop demanding a fully classical picture of microscopic events. Einstein (1905), de Broglie (1927), and Bohm (1952) made several attempts to interpret the events in the atom in a more intuitive way. In this paper we introduce the Planck action intensity h/4π with the dimension [Js steradian$^{-1}$]. The motion of quantum particle in this model is guided by the directed Planck action intensity as it was anticipated by de Broglie (1927) and Bohm (1952) in their pilot-wave models. This dimension of the Planck constant enables to interpret the mysterious "spin" in a new way. We will propose models of free electron, proton, and photon. The mathematical formulation of the special theory of relativity (STR) by Einstein (1905) can be visualized as a particle guided by the Planck action intensity on the elastic helix which can be compressed and expanded, and be measured as the blue- or redshifts of those particles. The apparent mass increase of electron or proton is caused by the effective cross section of that moving circular electron or proton in the electromagnetic field (EM).

**Keywords:** Classical Instructions for Electrons, Protons and Photons, Pictures of Events with Electrons, Protons, and Photons, Planck Action Intensity [Js Steradian$^{-1}$], A new Interpretation of the Special Theory of Relativity.

## 1. Introduction

The history of quantum mechanics is often told as a story of prohibition: one must not ask what happens "inside" the atom, one must not visualize microscopical reality classically, and one must be satisfied with predictive rules alone. That historical summary is too severe. What the founders actually demonstrated was not that visualization is impossible, but that naïve classical visualization is inadequate, e.g. [1]-[10]. The central question is therefore not whether atoms can be visualized in the old mechanical sense, but whether there exists a route toward a disciplined visual grammar that is faithful to both theory and experiment.

Louis de Broglie´s pilot-wave idea and David Bohm´s 1952 reinterpretation are the cleanest examples of an attempt to restore continuous individual processes without surrendering the empirical success of quantum mechanics. Bohm explicitly argued that one may obtain a precise and continuous description

**Citation:** Jiří STÁVEK. Can Steradians Modify Our Understanding of Quantum Mechanics and the Special Theory of Relativity?. Open Access Journal of Physics. 2026; 8(3): 01-08.

of quantum processes through additional variables guided by the wavefunction.

The gist of this paper is to introduce the Planck action intensity [Js steradian$^{-1}$] radiated from the quantum particle that serves as the guiding wave of that quantum particle.

## 2. The Dimensions of the Planck Constant

The Planck constant has now exact numerical value as h = 6.62607015*10$^{-34}$ J Hz$^{-1}$ in SI units. The closely related reduced Planck constant ħ – h/2π is commonly used in quantum physics equations with the dimension [Js radian$^{-1}$]. In this dimension the Planck constant relates the energy of a photon to its angular frequency, and the linear momentum of quantum particle to the angular wavenumber of its associated matter wave. The reduced Planck constant ħ is usually written with the dimension [Js] because the radian is the natural dimensionless unit of angle. What will happen with the interpretation of the reduced Planck constant if we will work with steradians instead of radians? This situation in expressed by Eq.1:

$$\frac{h}{2\pi} = 1.054\,571\,817... \times 10^{-34} \quad \left[\text{Js radian}^{-1}\right]$$
$$\frac{h}{2\pi} = 1.054\,571\,817... \times 10^{-34} \quad \left[\text{Js steradian}^{-1}\right] \qquad (1)$$

The solid angle (symbol: Ω) is a measure of the amount of the field view from a center of a sphere. The point from which the object is observed is called the apex of the solid angle, and the observed object is said to subtend its solid angle at that point. In SI units, a solid angle is expressed in a dimensionless unit called a steradian (symbol: sr), which is equal to one square radian, sr = rad$^2$. The total surface area of the unit sphere is 4π. Fig. 1 shows the solid angles with the values 2 sr, 1 sr, and 0.5 sr. The sphere has the radius R – Eq.2:

$$R = \frac{e}{\sqrt{4\pi\varepsilon_0 \alpha c}} \quad \left[\left(\text{Js sr}^{-1}\right)^{1/2}\right] \quad \frac{h}{2\pi} = R^2 \quad \left[\text{Js sr}^{-1}\right] \quad v = \alpha c \qquad (2)$$

where e is the elementary charge, $\varepsilon_0$ is the permittivity of vacuum, α is the fine structure constant, c is the light speed. In this model the velocity v = αc describes the velocity with which the Planck action intensity moves around that quantum particle.

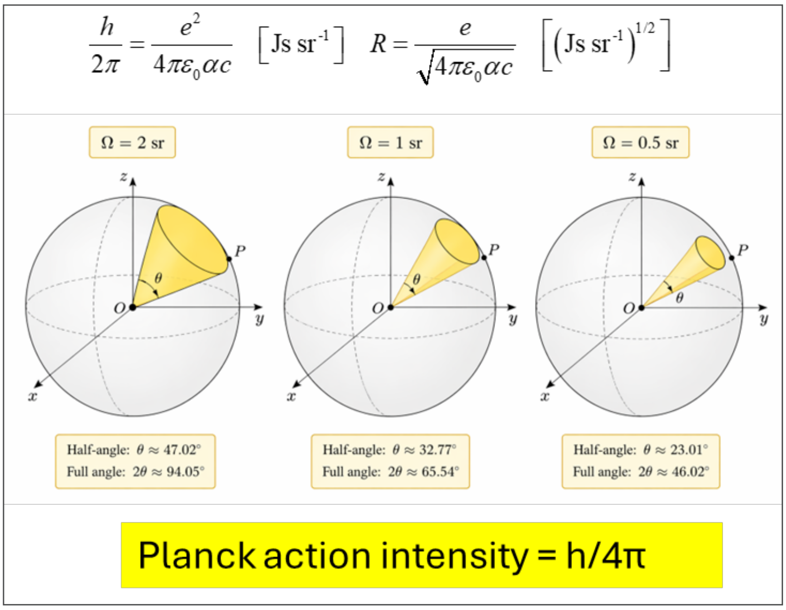


**Figure 1.** *The Planck constant modelled as the action intensity using the solid angles.*

## 3. An Attempt to Visualize the Motion of a Free Electron and the Planck Constant Dimensions

The Planck constant h is a fundamental physical constant in the realm of quantum mechanics and its numerical value was fixed as h = 6.62607015*10$^{-34}$ J Hz$^{-1}$ in SI units. The closely related reduced Planck constant proposed by Dirac as ħ – h/2π and by Heisenberg as ½ ħ in their models of quantum mechanics, are commonly used in quantum physics equations with the dimension [Js radian$^{-1}$], [11]-[20]. We propose to enter into these formulae steradians to describe the Planck action intensity of electron. The different angular functions lead to different interpretations of the Planck constant in the realm of quantum particles as it is shown in Fig. 2 for a free electron. In this model the free electron with mass $m_e$ is rotating around the empty center of the circle with radius $\lambda_e$ (the Compton wavelength) and the speed of light c. We can describe the rotation of this free electron using steradians. Therefore, the formula h/4π has the meaning of the Planck action intensity and is numerically identical with the mysterious spin of fermions.

The quantity h/4π appeared in several situations. E.g., the Bohr magneton $\mu_B$ can be obtained from the Dirac theory – Eq.3:

$$\mu_B = \frac{h}{4\pi}\frac{e}{m_e} \tag{3}$$

Schrödinger [21] derived from the Dirac theory the electron model under the name zitterbewegung that was many times modified during the past hundred years, e.g. [22]-[30], (see Ch.5 in this paper).

The Planck action intensity is pushing that electron on the circular path around an empty center. This model could represent the pilot-wave idea of de Broglie and Bohm. Fig. 3 depicts the motion of this circular electron through the electromagnetic field. The effective cross section of that electron decreases with its growing velocity v. This effect leads to the increased apparent mass of electron $m_{apparent}$ – Eq. 4:

$$\sigma_{eff} = \sqrt{1-\cos^2\theta}\,\sigma_e = \sqrt{1-\frac{v^2}{c^2}}\,\sigma_e$$
$$m_{apparent} = \frac{m_e}{\sqrt{1-\frac{v^2}{c^2}}} \tag{4}$$

This apparent mass of electron enters into the de Broglie´s formulae for momentum, wavelength and frequency of that electron: a physical interpretation of the Lorentz factor.

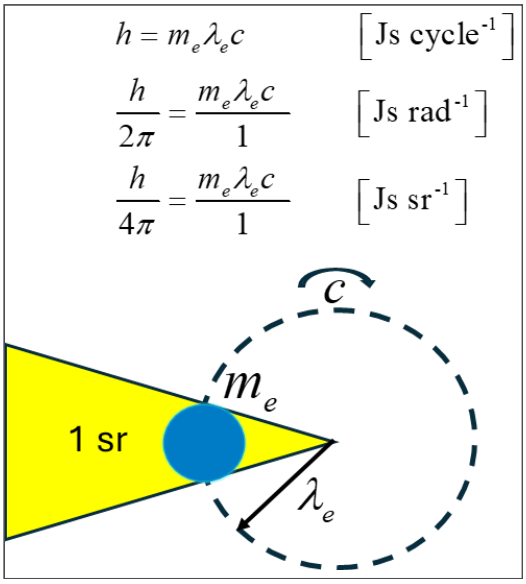


**Figure 2.** *The Planck action intensity h/4π pushing the electron with mass me on a circular path around the empty center with the Compton radius λe , c is the speed of light.*

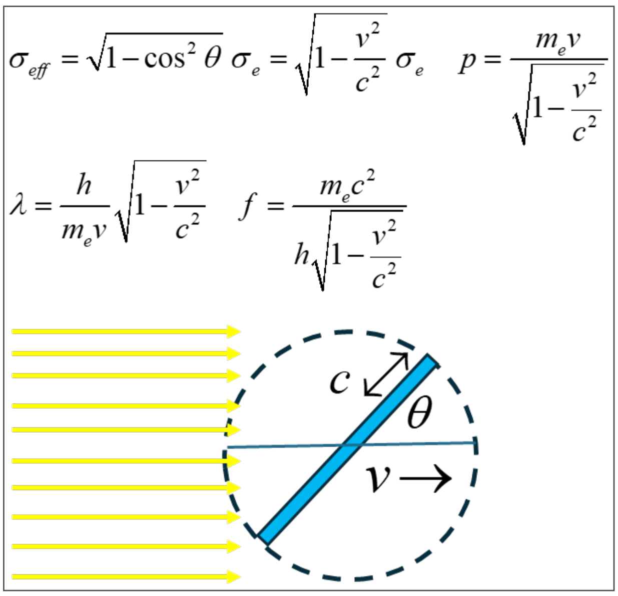


**Figure 3.** *The side view of a free circular electron moving through the electromagnetic field. The effective electron cross section σeff decreases with the growing electron velocity v in this EM field and modifies the momentum, wavelength, and frequency of that electron.*

## 4. An Attempt to Visualize the Motion of a Free Composite Proton and the Planck Constant Dimensions

A proton is a stable subatomic particle with mass $m_p$ and a positive electric charge +1 e. In the modern Standard Model of particle physics, protons are known to be composite particles of two up quarks of charge +2/3 e each, and one down quark of charge -1/3 e, e.g. [31]-[33]. Stávek [34] modeled this composite proton as two quarks with mass $m_p/2$ and charge +2/3 e rotating around the quark with mass $m_e$ and charge -1/3 e. This model is given by Fig. 4.

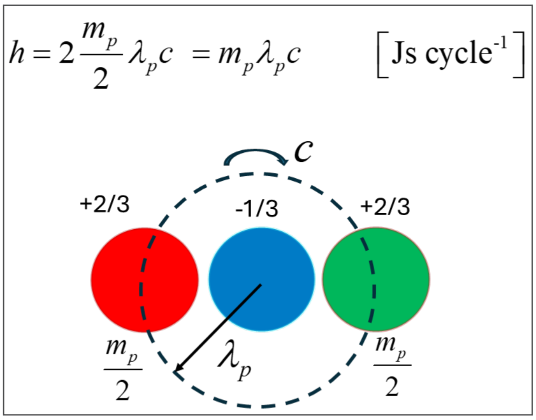


**Figure 4.** *The rotating composite proton with the radius λp = 1,32 fm (the Compton wavelength), the quark charge radius of the red and green quarks is about r = 0,84 fm (proton radius puzzle).*

The rotation of this composite circular proton creates the total action intensity h/4π composed from two contributions of red and green quarks h/8π. The total action intensity guides red and green quarks on their circular path around the blue quark with the charge -1/3 e. This possible scenario is given by Fig. 5.

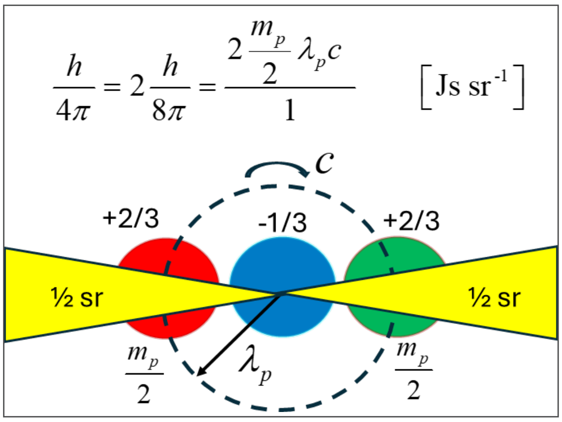


**Figure 5.** *The rotating composite proton with red, green and blue quarks radiating the Planck action intensity h/4π.*

Fig. 6 summarizes the properties of the de Broglie wave of the composite proton based on the effective proton cross section in the EM field– the Lorentz factor in the microworld.

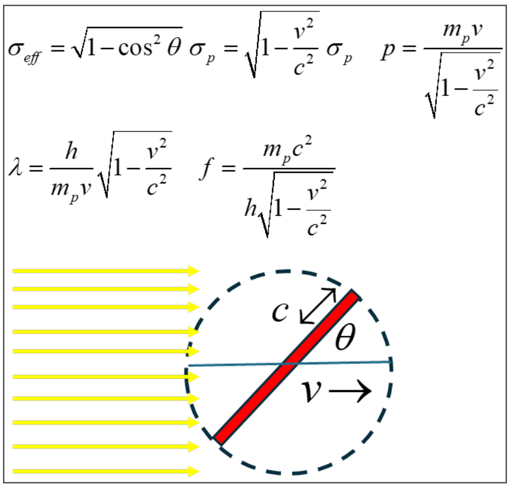


**Figure 6.** *The side view of a free circular composite proton moving through the electromagnetic field. The effective proton cross section σeff decreases with the growing proton velocity v in this EM field.*

## 5. An Attempt to Visualize the Motion of a Photon on the Elastic Helix Path and the Planck Constant Dimensions

Albert Einstein in 1905 published his masterpiece [35] "On the electrodynamics of moving bodies" with mathematical formulae that were experimentally confirmed with the greatest possible accuracy. Those mathematical formulae need only mathematics at high school level but fundamentally alters our understanding of the concept of time and space. Since that Einstein´s discovery we have to accept the elastic space-time.

However, there might exist one loophole in the interpretation of these mathematical formulae. Can we find a model where all mathematical formulae of the special theory of relativity are valid but the observed elasticity of photons is determined by an elastic route of those photons?

In this new scenario we propose to introduce the Planck action intensity of photons h/2π with the dimension of [Js sr⁻¹]. The Planck action intensity h/2π is guiding the photon on an elastic helix path where the compression and expansion of that helix is modified during photon contacts between the source and the observer based on their relative speed. This situation is given by Fig. 7.

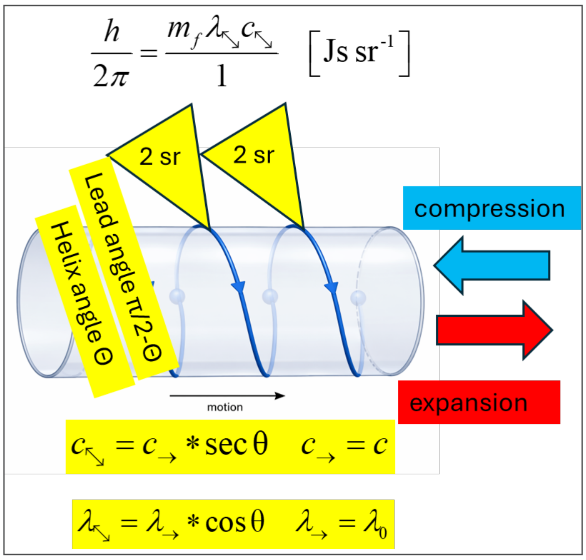


**Figure 7.** *The photon with mass mf is guided by the Planck action intensity on the elastic helix path. The elasticity of that helix enables the compression (blue shift) and expansion (red shift) of that helix based on the relative velocity of the source and the observer. The helix angle Θ modifies the resulting wavelength and frequency of that photon. The photon mass mf is constant during those compression or expansion events.*

This elastic helix and the Planck action intensity leads to the identical mathematical formulae as were derived by Albert Einstein in 1905 [35]. The visualization of the elastic helix path is shown by Fig. 8.

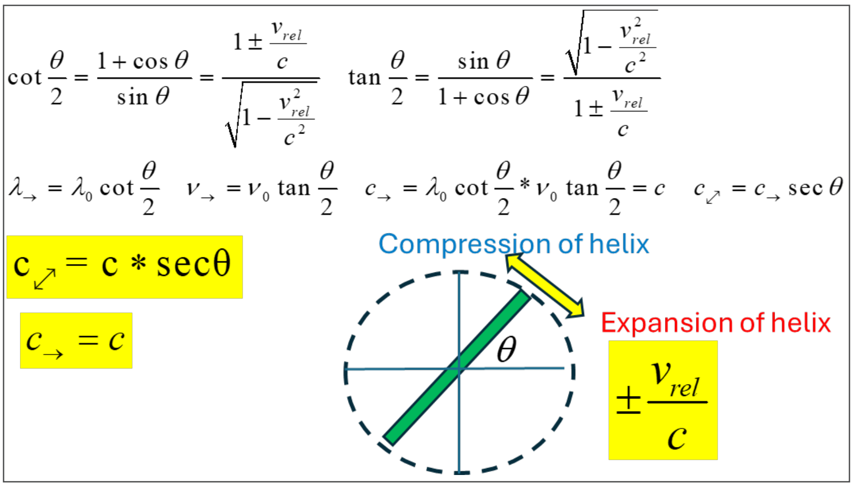


**Figure 8.** *The photon with mass mf is guided by the Planck action intensity on the elastic helix path. The elasticity of that helix enables the compression (blue shift) and expansion (red shift) of that helix based on the relative velocity of the source and the observer. The helix angle Θ modifies the resulting wavelength and frequency of that photon: we get the same mathematical formulae as in the STR but the physical reality is based on the elasticity of the photon path on the helix with the helix angle Θ.*

There is one new possible experimental fact that could extend the mathematical formulae of the STR. Until now all measurements of the light speed were done in the longitudinal direction of the motion of that photon (the longitudinal value c was introduced by Maxwell in 1864) - Equation 5

$$c_{\rightarrow} = \lambda_0 \cot\frac{\theta}{2} * \nu_0 \tan\frac{\theta}{2} = c \tag{5}$$

We know only one experiment where the value of the light speed could be measured in the direction of the helix angle ϴ. This was done by Weber and Kohlrausch in 1856 [36]-[37]

$$c_{\square} = c \sec\theta = c \sec 45^{\circ} = \sqrt{2}\, c = c_W \tag{6}$$

Therefore, it could be highly interesting to measure the value of the light speed in the direction of the helix angle for redshifted and blueshifted photons. Then, we can get a more general formula for the photon energy

$$E = mc^2 \sec^2\theta \tag{7}$$

Schrödinger in 1930 derived from the Dirac theory an equation with the effect termed as zitterbewegung:

$$\hbar\omega = 2mc^2 \tag{8}$$

There were many attempts during the past hundred years to find an interpretation of this formula, e.g. [22]-[30]. The Planck constant used in the Schrödinger´s zitterbewegung formula has the dimension [Js $rad^{-1}$]. If we will use the Planck constant with the dimension [Js $sr^{-1}$], ω with the dimension [sr $s^{-1}$], and the Weber´s light speed $c_W = \sqrt{2}\, c$, we can get the interpretation of zitterbewegung as

$$\frac{h}{2\pi} 2\pi\nu = mc_W^2 = mc^2 \sec^2\frac{\pi}{4} = 2mc^2 \tag{9}$$

Schrödinger´s zitterbewegung formula describes the motion of a quantum particle on the helix with the helix angle ϴ = 45°.

## 6. The Orientation of the Solid Angle and the Planck Action Intensity in the 3D Space

The motion of quantum particles in the 3D space can be influenced by the orientation of a solid angle and the Planck action intensity: dependence on the zenith angle ϴ and azimuthal angle Φ. Figure 9 survey some orientations of the solid angles. This could be a new view into the inner architecture of quantum particles.

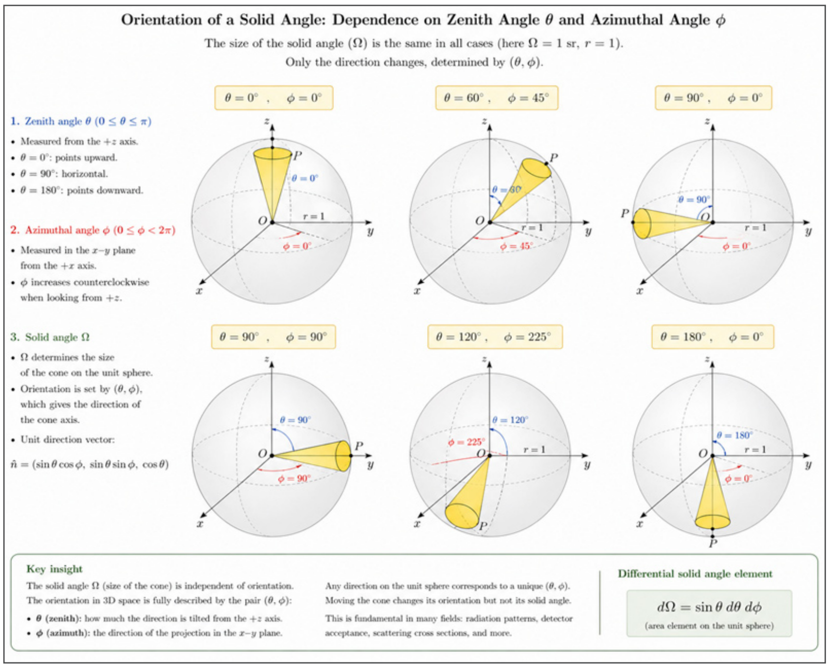


**Figure 9.** *The orientation of the solid angle and the Planck action intensity could open a new view into the inner architecture of quantum particles.*

## 7. Conclusion

The inner architecture of atoms should not be treated as a forbidden city. It is better understood as a partially hidden structure whose entryways have been opened, closed, and reopened in different forms over the last hundred years. The great lesson of 1926-2026 is not that atomic reality is beyond thought, but that it demands new kinds of thought. One possibility could be the Planck action intensity as a "hidden" guiding wave of quantum particles.

Louis de Broglie at the Solvay Conference in 1927 [38]: „So far we have considered the corpuscles as ´exterior´ to the wave Ψ = a cos[(2π/h) φ], their motion being only determined by the propagation of the wave. This is, no doubt, only a provisional point of view: a true theory of the atomic structure of matter and radiation should, it seems to us, *incorporate* the corpuscles in the wave phenomenon by considering singular solutions of the wave equations.“

**Acknowledgment**

We were supported by the contract number 0110/2020.

**Conflict of Interest**

The author declares that there is no conflict of interest.

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