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# The Mechanism of Action of Coronavirus through a Minimal Measurable Momentum

Maryam ROUSHAN* and Narges RASHIDI†
Department of Theoretical Physics, Faculty of Science, University of Mazandaran,
P. O. Box 47416-95447, Babolsar, Iran
ICRANet-Mazandaran, University of Mazandaran, P. O. Box 47416-95447, Babolsar, Iran

**Abstract**

Laboratory data suggest that coronavirus (Covid 19) can spread from infected people to other people through airborne transmission. In this paper, we want to explain this phenomenon with quantum gravitational effects as a minimal measurable momentum. We will show that when virus droplets (which have velocities) propagate from a specific source (e.g., coughing, sneezing, or talking), they remain suspended in spacetime due to the existence of a minimal measurable momentum. Because the momentum of these particles is never zero in this situation. In this regard, we solve equations of motion in the presence of a minimal measurable momentum for virus-carrying particles and we obtain trajectories of them in the phase space.
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## 1 Introduction

It is a well-known fact respiratory viruses are transmitted in three approaches: direct touch, droplets, and airborne transmission. Recent studies have shown that the coronavirus is transmitted by tiny respiratory particles that are suspended in the air, and humans become infected by breathing in this air. Indeed, respiratory fluids during exhalation of the people carrying the disease are in the form of droplets that carry the virus and transmit infection. Virologists believe that the largest droplets settle out of the air quickly, through seconds, and the smallest one very fine droplets and aerosol particles are small sufficient that they can remain suspended in the air for hours [1, 2, 3]. Our goal in conducting this research is to show the physical behavior of these particles and their suspension in space. In fact, we will show that the virus-carrying particles that are released are constantly dynamic and present in the air and can transmit the disease until they lose their pathogenicity.

Accepting this hypothesis requires being able to know the physics of space (or from the point of view of physicists “spacetime") around us. According to new theories that

*m.roushan@umz.ac.ir (Corresponding Author)
†n.rashidi@umz.ac.ir

have received much attention from physicists recently, the structure of spacetime is not continuous in the presence of some natural cutoffs in its essence [4, 5, 6, 7, 8]. In this regard, many concepts of quantum mechanics, including the Uncertainty Principle, are modified so that we have the Generalized Uncertainty principle and Extended Uncertainty Principle. In this respect, Heisenberg's algebraic position and momentum operators are being redefined to cover this discretization [9, 10].

In this paper, we discuss that airborne virus transmission is one of the most likely mechanisms in this regard. It should be noted that we have nothing to do with the shelf life of this virus and its pathogenicity (in this case, its experts should comment). In fact, we will only study the physical behavior of the virus-carrying particles in spacetime under the quantum gravitational effects. In this regard, we will show that due to the quantum gravitational effects, the virus-carrying particles do not stop moving as long as it is alive and is constantly moving because there is always a minimal measurable momentum in the structure of spacetime [11, 12, 13] that can't be zeroed. In other language, it seems that the spread of the virus can be affected by the quantum gravitational effects.

The paper is organized as follows: in section 2 we initiate with the Heisenberg Uncertainty Principle in the presence of minimal momentum (as a trace of quantum gravitational effect) as an inherent natural cutoff in the spacetime configuration and we institute modified phase space operators. In section 3, we show phase space trajectories of a particle undergoing quantum gravitational effects. For this purpose, we consider the matter case described by an action in the background of a flat FLRW cosmology. In this procedure, we find Lagrangian for the FLRW cosmological system by this action and we obtain equations of motion in the presence of the natural cutoff. By studying these trajectories, we will see that quantum gravitational effects can have major effects on the behavior of virus-carrying particles in spacetime. Certainly, in the presence of a minimal measurable momentum as a constraint on the structure of spacetime causes the virus-carrying particles to constantly move until they lose their pathogenicity. Finally, we will summarize the results in section4.

# 2 Minimal measurable momentum in spacetime configuration

Intrinsically, the fabric of spacetime in the presence of quantum gravitational effects includes some natural cutoffs through which finds a discrete structure. In other words, spacetime is a noncommutative structure in this background. Therefore, the algebra of commutative spacetime in quantum mechanics requires fundamental modifications. Noncommutative spacetimes are defined in the context of Extended Uncertainty Principle (EUP) through canonical conjugates $(X, P)$ which refers to a minimal measurable momentum as a natural cutoff suggested by

$$\Delta X \Delta P \geq \frac{1}{2}\Big(1 + \eta(\Delta X)^2\Big)\,. \tag{1}$$

Equation (1) follows the noncommutative algebra of phase space and canonical commutation relation corresponding to (1) is established between the elements of this algebra

$$\Big[X, P\Big] = i\Big(1 + \eta X^2\Big)\,, \tag{2}$$

Note that the momenta are also noncommutative in this structure. Consequently, the minimal uncertainty for momentum measurement is presented by [9]

$$(\Delta P)_{min} = \sqrt{\eta}\,. \tag{3}$$

In this modified structure in the presence of a minimal measurable momentum, the position and momentum operators are also corrected as follows

$$X = x, \qquad P = p(1 + \eta X^2)\,. \tag{4}$$

These corrections are such that they cover the gap of uncertainty. We have studied more detailed descriptions of these relationships in our works [10].

# 3 Phase Space Trajectories of a particle undergoing quantum gravitational effects

After introducing the formalism of the algebraic structures in the presence of a minimal measurable momentum (modified algebraic structure of quantum mechanics), in this part, we attempt to solve equations of motion of virus-carrying particles in the presence of this natural cutoff. In the following, we obtain phase space trajectories of these particles.

we begin with the familiar Friedmann-Lemaître-Robertson-Walker metric (FRW) in a isotropic and homogeneous universe for matter case as

$$ds^2 = -dt^2 + a^2(t)\left(\frac{dr^2}{1-kr^2} + r^2 d\Omega^2\right), \tag{5}$$

where $a(t)$ indicates the cosmological scale factor. Here, we consider $k = 0$ (a flat universe), so the action functional with this metric is described by the following equation

$$\begin{aligned} S &= \frac{m_p^2}{2}\int \sqrt{-g}Rd^4x + \int \sqrt{-g}\rho d^4x \\ &= \frac{m_p^2}{2}\int -6a\dot{a}^2 d^4x + \int a^3\rho d^4x\,, \end{aligned} \tag{6}$$

where $R$ is Ricci scalar, $g$ is the determinant of the metric and $m_p$ is Planck Mass.

Now, we get the corresponding lagrangian

$$L = a_0^3\Big(-3m_p^2 x\dot{x}^2 + \rho_0 x^{-3w}\Big)\,, \tag{7}$$

where $\rho = \rho_0(\frac{a}{a_0})^{-3w}$, $\frac{a}{a_0} = x$ and $w$ is the equation of state.

Consequently, we obtain the conjugate momentum $p = \frac{\partial L}{\partial \dot{x}} = -2a_0^3 m_p^2 x\dot{x}$.

Hence, the Hamiltonian parallel to the Lagrangian according to

$$H = -\frac{p^2}{12a_0^3 m_p^2 x} - a_0^3\rho_0 x^{-3w}\,. \tag{8}$$

Now, we obtain modified Hamiltonian By setting (4) in (8) in the following steps

$$H = -\frac{P^2}{12a_0^3 m_p^2 X} - a_0^3\rho_0 X^{-3w}$$

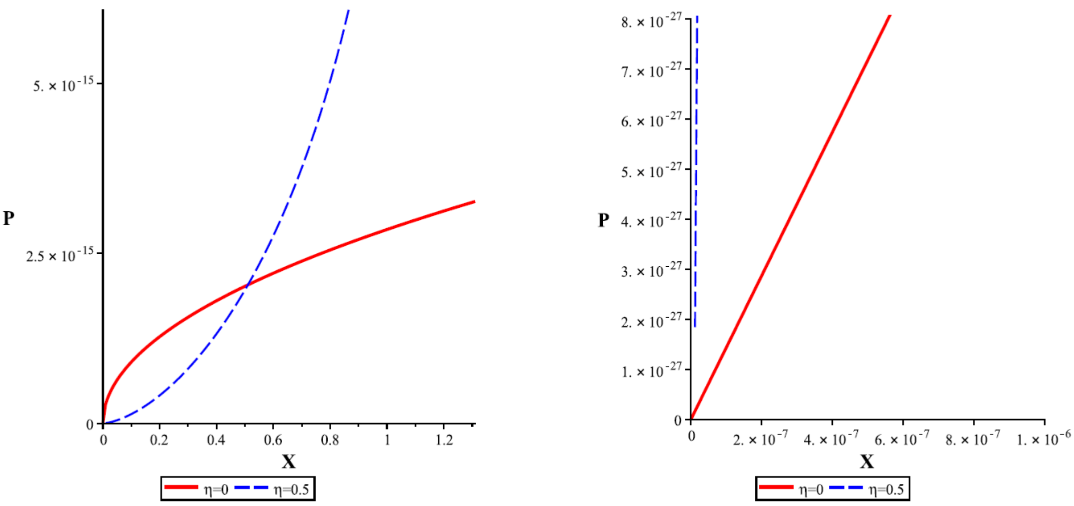


Figure 1: Phase space trajectories of a virus-carrying particle in the presence of minimal momentum. In the right panel, we have zoomed out the left panel to show the differences from the standard model more clearly.

$$= -\frac{p^2(1+\eta x^2)^2}{12 a_0^3 m_p^2 x} - a_0^3 \rho_0 x^{-3w} \,. \tag{9}$$

Given in this situation, we are able to obtain equations of motion in the following

$$\dot{x} = \frac{\partial H}{\partial p} = -\frac{1}{6}\frac{p(1+\eta x^2)^2}{a_0^3 m_p^2 x} \,, \tag{10}$$

$$\dot{p} = -\frac{\partial H}{\partial x} = \frac{\eta p^2(1+\eta x^2)}{3 a_0^3 m_p^2} - \frac{p^2(1+\eta x^2)^2}{12 a_0^3 m_p^2 x^2} - 3 a_0^3 w \rho_0 x^{-3w-1} \,. \tag{11}$$

Therefore, using Eq. 10 and Eq. 11, we can obtain the equations of motion and show the trajectory of the phase space of a particle undergoing quantum gravitational effects.

Figure 1 shows the phase space trajectories of a virus-carrying particle in the presence of minimal momentum cutoff. The significant point is that, due to the existence of minimal momentum (energy), the trajectories are bounded from below. The right panel shows well that the momentum of a such particle never becomes zero (dashed line) and there is always a minimal momentum for the particle in spacetime structure. It seems that if we consider the effects of the natural cutoffs, the momentum of the coronavirus never becomes zero. In this regard, it never stops transmitting. Of course, this argument is from a physical point of view, and the rest of the scenario depends on the pathogenicity of this virus. Note that, in the sense that we consider the coronavirus as ordinary matter with $w = 0$, the last term in equation (11) has no effects on figure 1.

# 4 Conclusion

In this paper, we have investigated the behavior of a virus-carrying test particle undergoing quantum gravitational effects. In this regard, we have fabricated the phase space representations of quantum mechanics with the natural cutoff as a minimal measurable momentum [9, 12]. In fact, we have demonstrated that the existence of a minimal momentum cutoff leads to a noncommutative phase space with a discrete configuration. Meanwhile, we proposed a new definition of position and momentum operator [13]. On the other hand, there is ample epidemiological evidence that airborne transmission plays a very important role in the spread of the virus [14]. From this perspective, we believe that the presence of a natural infrared cutoff (minimum momentum constraint) in the fabric of spacetime causes the virus-carrying particles to be constantly in motion and to behave dynamically. In other words, the existence of a minimal momentum confirm that airborne transmission can be as the dominant path for the spread of virus-carrying particles. For this purpose, and to clarify the issue, we have considered virus-carrying particles as ordinary matter. In this regard, by writing the desired action in the FLRW cosmological context that has led to the Lagrangian of this system and using the Hamiltonian of these particles, which represents the energy of the system, we were able to obtain the equations of motion. In this respect, we have illustrated the phase space trajectories. The significant attribute is that this natural cutoff makes the trajectories to be bounded from below in the phase space.

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