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DISCOURSE ON THE SECOND QUANTUM REVOLUTION AND NANOTECHNOLOGY APPLICATIONS IN THE MIDST OF THE COVID-19 PANDEMIC OF INEQUALITY

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***Abstract :** Everything (all processes) is very fast moving and changing in the era we live in. Perhaps the best application of this transformation, the sample will be quantum computers. With the 2nd quantum revolution, new developments in science and technology are now viewed from a different perspective. In this article, we will briefly examine what will change in the future with this perspective. Surely the future will surprise us more than we ever imagined. The Weyl, Majorana fermions and monolayers are good example of interesting transformations from Particle Physics to Condensed Matter Physics, Electronics, Materials Science, Materials Chemistry, even Nanomedicine and Medical Physics amid the novel coronavirus. The Nanotechnology, on the other hand, has become an indispensable component of all branches of science.*

***Keywords-** COVID-19, Monolayers, Nanostructure, Nanotechnology, 2nd Quantum Revolution*

I. INTRODUCTION

The new quantum mechanics, when applied to the problem of the structure of the atom with point-charge electrons, does not give results in agreement with experiment [1]. The quantum description of spin-1/2 particles is given by the solutions of the Dirac equation. In 1929, one year after Paul A. M. Dirac published it (electrons in free space are Dirac fermions), Hermann Weyl reported that, for massless particles, the equation could be split into a system of two equations whose solutions are distinguished by chirality. These massless spin-1/2 particles, so-called Weyl fermions, have never been found in nature [2]. Predicted theoretically Weyl Fermion in 1929 [3] by Hermann Weyl and, Majorana Fermion in 1937 by Ettore Majorana [4]. Their experimental discoveries by scientists only came in 2008-2018 with ARPES (Angle-Resolved PhotoEmission Spectroscopy) and STM (Scanning Tunnel Spectroscopy). These fermions could play an intriguing role. Prior research has shown that fermions that adhere to theorem exist as quasiparticles in some solids (Weyl Semimetals (WSM), etc.). Notably, they behave differently than electrons in metals. In 1937, physicist Conyers Herring theoretically identified the conditions under which electronic bands in solids have the same energy and momentum in crystals that lack inversion symmetry [5, 6]. For some time, it was thought that neutrinos were Weyl fermions, but now it looks almost certain that neutrinos have mass and are therefore not Weyl particles [7-9]. The discovery of neutrino oscillations was announced in 1998. 2 years after the start of the operation and the evidence of the solar neutrino oscillation was shown by the data from SNO and Super-K (Super-Kamiokande) in 2001. Detailed studies on the neutrino oscillations have been going on since the discoveries. Hyper-Kamiokande (Hyper-K) with 8 times bigger fiducial mass than Super-K is planned in Japan (expected to start in 2028) [10].

The search for topological states of quantum matter has attracted intensive interest in condensed matter physics. The quantum Hall effect (QHE), discovered in 2D electron systems in 1980s [11]. Report the observation of the quantum anomalous Hall (QAH) effect in thin films of chromium-doped (Bi,Sb)2Te3, a magnetic topological insulator [12]. The anomalous Hall effect (AHE) is one of the most famous transport phenomena in magnetic materials. The semiclassical theory of the anomalous Hall effect induced by the Berry curvature in Bloch bands has been introduced. The theory operates only with gauge invariant concepts that have a simple semiclassical interpretation and provides a clear distinction among various contributions to the Hall current. Many theoretical constructions that usually had been considered of relevance mainly in high energy physics such as non-commuting coordinates and magnetic monopoles, became useful and even measurable in experiments on the AHE [13]. The anomalous Hall effect has deep roots in the history of electricity and magnetism. In 1879 Edwin Herbert Hall [14] made the momentous discovery that, when a current-carrying conductor is placed in a magnetic field, the Lorentz force "presses" its electrons against one side of the conductor. One year later, he reported that his "pressing electricity" effect was ten times larger in ferromagnetic iron [15] than in non-magnetic conductors [16].

II. THE 2ND QUANTUM REVOLUTION

The Classical Mechanics revolution, the 1st Quantum and Relativity revolution and, finally in the 2nd Quantum revolution aims to bring a new epoch of weirdness or striking technologies (superposition, entanglement (Quantizing multi-qubit entanglement is important for quantum information processing communication [49]), qubit, qudit, qumode (Continuous Variable, CV), zeromode, etc.) that will use quantum physics to improve their capabilities (Future and Emerging Technology (FET), Nanotechnologies (nanowire (nanohashtag, nano#), nanorod, nanoparticle, nanofiber, etc.), Quantum Information Technologies, Quantum Key Distribution, Quantum Computer and Computing, Quantum Communication, Quantum Enabled Security Technologies, Quantum Simulation, Quantum Sensing and Control, etc.). In this period, those who were pure theoretical, particle physics or problem have now become experimental (condensed matter, etc.) physics.

The violation of a Bell inequality not only attests to the nonclassical nature of a system but also holds a very unique status within the quantum world. The amount by which the inequality is violated often provides a good benchmark on how a quantum protocol will perform. Acquiring images of such a fundamental quantum effect is a demonstration that images can capture and exploit the essence of the quantum world. The violation of a Bell inequality is a fundamental manifestation of a quantum system. Not only does it attest to the quantum spookiness of the behavior of a system, but it also benchmarks the performance of these systems when involved in certain quantum protocols. For example, certain quantum protocols require Bell-type nonlocal behaviors to be performed such as device-independent protocols. One quantum technology that is currently of interest is quantum imaging that attempts to use the quantum behavior of light to perform new types of imaging that are capable of surpassing the limits of classical methods. As such, acquiring images of one of the most fundamental quantum effects is a demonstration that images can be exploited to access the full range of possibilities allowed in the quantum world. This result both opens the way to new quantum imaging schemes based on the violation of a Bell inequality and suggests promise for quantum information schemes based on spatial variables [17].

New a lot of tools (PennyLane, Strawberry Fields, Rigetti Forest, Qiskit, Microsoft QDK, ProjectQ, TensorFlow, PyTorch, Autograd, IBM Q, Google Cirq, NumPy, TensorFlow, OpenQASM [18], Quirk (Quantum Circuit Simulator), etc.) available to investigate model structures, training strategies, and optimization landscapes within hybrid and quantum machine learning, to explore existing and new variational circuit architectures, and to design completely new algorithms by circuit learning [19]. In the coming days could open the way for entangled, less expensive, more powerful and, will open an avenue towards further exploration (in line with current and new insights developments) of quantum computers running at room temperature.

III. SOME STUDIES PAVING THE WAY FOR NANOTECHNOLOGY APPLICATIONS

If studies are desired to be listed item by item:

1. We describe another (theoretically, much simpler) way to construct decoherence-protected degrees of freedom in one-dimensional systems ("quantum wires"). Although it does not automatically provide fault-tolerance for quantum gates, it should allow, when implemented, to build a reliable quantum memory. We will show that Majorana fermions can also occur at the ends of quantum wires. The particular mechanism of superconductivity is not important; we may just think that our quantum wire lies on the surface of 3-dimensional superconductor. Suppose that the superconducting island supporting the quantum wire is connected to a larger piece of superconductor through an ordinary Josephson junction. If the Coulomb energy is comparable to the Josephson energy, spontaneous phase slips can occur [20].

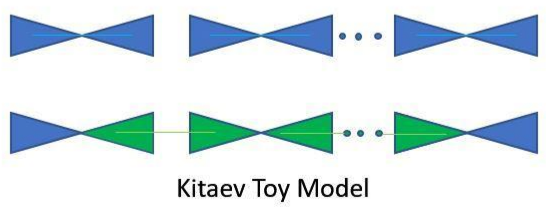

Fig. 1 Kitaev Chain Model [20, 26], reimaged by Mehmet Keçeci

2. Semiconductor nanowires are the primary contender for realizing a topological quantum bit (qubit) based on Majorana modes. Their confined geometry together with the highly tunable electronic properties readily allow for localizing Majoranas, engineering the coupling between Majoranas, and finally controlling the coupling between the topological superconductor and the external circuity. These requirements for the implementation of a Majorana qubit are challenging to achieve in other Majorana systems such as 2D and 3D topological insulators. Moreover, various basic networks and high-quality interfaces to different superconductors have already been realized in semiconductor nanowires, fulfilling the further requirements for Majorana qubits [21].
3. The perfect transmission regions can be selected by tuning the magnetic fields which may be used to generate localized transmission in the bulk of Weyl semimetals, a prediction which may be utilized in electro-optic applications [22].
4. Importantly, our data verify that the band never crosses E_F near the M point as predicted by the calculations, leaving only the novel fermions near Γ and R to be relevant to low-energy physics. This would be favorable for observing predicted unconventional physical properties related to the chiral fermions at even lower temperatures [23].

5. When magnetic field is applied to this system to break TR (time-reversal) symmetry, these quasiparticles will split to multiple Weyl fermions, and the anomalous magnetoresistance and chiral anomaly can be detected by transport measurements. Therefore, this work not only identities a series of desired robust topological semimetal candidates, but also provides an ideal platform to explore exotic physical phenomena and future device applications [24].
6. Finally, it would be interesting to introduce superconductivity or magnetism in these new topological metals. In particular, breaking time-reversal symmetry via magnetism can split the Dirac nodes into Weyl nodes [25].
7. Majorana zero modes are believed to exhibit the so called non-Abelian exchange statistics which endows them with a technological potential as building blocks of future quantum memory immune against many sources of decoherence which plague other such proposed devices [26].
8. Majorana zero modes are localized quasiparticles that obey non-Abelian exchange statistics. Braiding Majorana zero modes forms the basis of topologically protected quantum operations which could in principle significantly reduce qubit decoherence and gate control errors in the device level. Therefore, searching for Majorana zero modes in various solid-state systems is a major topic in condensed matter physics and quantum computer science. Since the first experimental signature observed in hybrid superconductor-semiconductor nanowire devices, this field has witnessed a dramatic expansion in material science, transport experiments and theory. While making the first topological qubit based on these Majorana nanowires is currently an on-going effort, several related important transport experiments are still being pursued in the near term. These will not only serve as intermediate steps but also show Majorana physics in a more fundamental aspect. In this perspective, we summarize these key Majorana experiments and the potential challenges [27].
9. Weyl semimetals are characterized by their bulk Weyl points - conical band touching points that carry a topological monopole charge - and Fermi arc states that span between the Weyl points on the surface of the material. Recently, significant progress has been made towards understanding and measuring the physical properties of Weyl semimetals. Yet, potential applications remain relatively sparse. Here, we propose Weyl semimetal nanowires as field-effect transistors, dubbed WEYLFETs. Specifically, applying gradient gate voltage along the nanowire, an electrical field is generated that effectively tilts the open surfaces, thus, varying the relative orientation between Fermi arcs on different surfaces. As a result, perfect negative refraction between adjacent surfaces can occur and longitudinal conductance along the wire is suppressed. The WEYLFET offers a high on/off ratio with low power consumption. Adverse effects due to dispersive Fermi arcs and surface disorder are studied [28].
10. A scalable manufacturing process for complex, high-quality superconductor /topological insulator structures could, in future, enable the production of topological quantum computation architectures [29].
11. Proximity-induced superconducting energy gap in the surface states of topological insulators has been predicted to host the much wanted Majorana fermions for fault-tolerant quantum computation. Recent theoretically proposed architectures for topological quantum computation via Majoranas are based on large networks of Kitaev's one-dimensional quantum wires, which pose a huge experimental challenge in terms of scalability of the current single nanowire-based devices. Here, we address this problem by realizing robust superconductivity in junctions of fabricated topological insulator (Bi_2Se_3) nanowires proximity-coupled to conventional s-wave superconducting (W) electrodes. Milling technique possesses great potential in fabrication of any desired shapes and structures at nanoscale level, and therefore can be effectively utilized to scale-up the existing single nanowire-based design into nanowire-based network architectures. We demonstrate the dominant role of ballistic topological surface states in propagating the long-range proximity induced superconducting order with high IcRN product in long Bi_2Se_3 junctions. Large upper critical magnetic fields exceeding the Chandrasekhar-Clogston limit suggests the existence of robust superconducting order with spin-triplet cooper pairing. An unconventional inverse dependence of IcRN product on the width of the nanowire junction was also observed [30].
12. A novel method for advanced nanomaterials obtainment. The goal of the research was to prepare efficient polymeric-carbon quantum dots (QDs) using poly(lysine) as a precursor according to green chemistry principles. The influence of microwave-irradiation time and carbonizing agent on CQD (Carbon Quantum Dot) physicochemical and biological properties was evaluated. The prepared bionanomaterials have a great potential in medicine and pharmacy and may be applied successfully in optoelectronics [31].
13. Multiferroic materials, in which ferromagnetism and ferroelectricity coexist, have attracted intense scientific and technological interest in recent years [32].
14. Synthetic protocol paves the way for the preparation of a new generation of metal nanoclusters protected by macrocyclic ligands with molecular recognition and selectivity toward specific guests. Ligand protected atomically precise metal nanoclusters (NCs) have generated great interest due to their unique physical and chemical properties. They are used in several areas including catalysis, sensing, imaging and drug delivery. Most of the NCs have a core-shell structure consisting of a metal atom core surrounded by a shell of metal-ligand

staple motifs. Hence, surface ligands play a vital role in determining the stability, atom packing as well as shaping the electronic properties of the NCs. Several ligands including alkane thiols, aromatic thiols, peptides, DNA, proteins, dendrimers, polymers, and phosphines have been used extensively for cluster synthesis [33].

15. The nonorthogonal configurations are clearly reflected in the shape of the hysteresis loops measured in both polar and longitudinal geometries. It is shown that even a tiny difference in system energy, caused, e.g., by a small magnetic field, results in a remarkable change of the magnetic configuration. A more detailed picture could result from a depth resolved experiment like coherent nuclear resonant scattering of synchrotron radiation which is currently under preparation [34].
16. Understanding the non-perturbative properties of QCD is one of the most difficult and intriguing research topics of the in strong interactions. The investigation of the hadron spectrum can play an important role in achieving this goal. According to QCD, not only traditional mesons and baryons, but also exotic particles such as glueball, hybrid and multiquark states can be observed [35].
17. In accordance with this change in the magnetization direction at lower temperatures, the sample shows an unexpected coexistence of perpendicular and in-plane exchange bias below the antiferromagnetic transition of CoO. The temperature dependence of the exchange bias field for both directions is also significantly different. The mechanisms behind this anomalous temperature dependence of the exchange bias as well as the step-like behaviour in the hysteresis curves are discussed [36].
18. The potential applications of nanorods are very attractive for bio-sensor, magneto-electronic, plasmonic state, nano-transistor, data storage media, etc [37].
19. Lagrangian approach permits a perturbative analysis of field theory in powers of the Planck constant and captures some semi-classical non-perturbative effects (such as instantons, merons, and solitons). Conformal symmetry is not realized in nature. In any realistic model, conformal symmetry needs to be broken. But it does play an important role in all kinds of physics. Conformal Field Theory (CFT) models constitute the essential building blocks of the classical vacua of string theory, including quantum gravity. CFTs are conformally invariant field theories, primarily in two space-time dimensions and are related to critical phenomena in statistical mechanical systems, and characterize their Renormalization Group (RG) fixed points. For that reason, they have numerous condensed matter applications. CFT describes classical string theory background configurations and is the basic tool to study their perturbative physics. There are a large number of interesting mathematical structures [38].
20. System Boundary; Though it is the sum of the perceptions of past and the perceptions of the present, it is as much as we can imagine and we can do something with it [39].
21. Kitaev Chain Model [20, 26], Topological Insulator (TI) edges, Non-abelian Statistics, Floquet Topological Insulators, New Fermionic Materials, New Quantum Computer CPUs, etc.

IV. INTRODUCTION TO NANOTECHNOLOGY APPLICATIONS FOR NANOMEDICINE

The ongoing COVID-19 crisis has completely changed life as we know it. Universities and schools are closed, restaurants are deserted, bars are shuttered, and people are working remotely from the safety of their homes. Lectures are moved from the classroom to Zoom chats, exams are taken online, and PhDs are defended remotely [40]. Normally, it was COVID-19 (Coronavirus Disease 2019, Novel Coronavirus (2019-nCoV), SARS-CoV-2) that changed everything while these studies were going on. The COVID-19 pandemic suddenly and abruptly changed the usual rhythm and conditions of our existence and has posed critical challenges for the public health, research, and the medical communities [41, 42]. This rapid change is already showing tangible effects in the environmental domain, where the vast majority of emissions associated with world-wide human agency is now suddenly on hold, possibly for the very first time in post-industrial history [43]. It will also play an important role in detecting, diagnosing and purification of viruses in all other fluids, such as purification of new emerging contaminants in water [44]. Growth of world population, developments of industry and intensive agricultural applications cause significant environmental problems and decrease the freshwater quality. Water pollution and lack of access to clean water resources have nearly become a limiting factor for the mankind [45]. Novel and emerging methods having a potential to contribute to sustainable and economical membrane fouling mitigation in the future [46]. Membrane and hydrogen separation technologies have come into prominence at this point [47]. Because viruses are approximately 18-500 nanometers. This opens the door to nanotechnology and nanostructures. For example, in many other areas, there may be unexpected developments such as the phenomenon: The intricate interplay of atomic, molecular, and nuclear science, together with highly fortuitous accidents in the molecular dynamics and the hope of practical application, breathed life into a seeming curiosity. A small but vigorous worldwide community has explored these myriad phenomena in the past 50 years [48]. On the other hand, anyonic studies are also important steps: Quantum theory requires that all fundamental particles must be fermions or bosons, which has profound implications for particles' statistical behavior. However, theoretical works have shown that in two dimensions it is possible for particles to violate this principle and obey so-called anyonic statistics, in which exchange of particle position results in a quantum mechanical phase change that is not π or 2π (as for fermions or bosons), but a rational fraction of π. While anyons cannot exist as fundamental particles in nature, certain condensed matter systems are predicted to host exotic quasiparticles which obey a certain form of anyonic statistics [50]. Thermal measurements (in vitro) at the nanoscale are key for designing technologies in many areas, including drug delivery systems, photothermal therapies, and nanoscale motion devices [51]. Quantum dots (QDs) are nanocrystals with bright fluorescence and long-term photostability, attributes particularly beneficial for single-molecule imaging and molecular counting in the life sciences. The size of a QD nanocrystal determines its physicochemical and photophysical properties, both of which dictate the success of imaging applications. Larger nanocrystals typically have better optical properties, with higher brightness, red-shifted emission, reduced blinking, and greater stability [52]. In order to characterize thermal dependent physical properties of materials, potentially to be used in technological applications, an accurate interatomic-potential parameter set is a must. Transition metal dichalcogenides (TMDs) are layered materials having the chemical formula MX_2, where M is a transition metal atom (i.e., Mo, W, Nb) and X is a chalcogen atom (i.e., S, Se, Te). The TMDs can exhibit different electronic properties such as semiconducting (as in MoS_2 and WS_2), metallic (as in WTe_2 and NbS_2) and even superconducting (as in $NbSe_2$ and TaS_2). Nowadays with the advance of fabrication technologies, the low-dimensional (LD) structures of these materials can be fabricated and used in device and sensor applications. It has already proven that these materials have great potential to be used in various future technological applications such as transistors, high speed electronics, emitters, detectors, next-generation solar cells, LEDs, photodetectors, fuel cells, photocatalytic, flexible devices and touchscreen display panels that have more powerful, faster, smaller and more efficient characteristics than those currently existing [53]. Finally, while the last 20 years of nanomedicine has, to a large extent, been underpinned by materials design, it is likely that the next 20 years will see research driven more by clinical needs [54]. Bacteria mediated infections may cause various acute or chronic illnesses and antibiotic resistance in pathogenic bacteria has become a serious health problem around the world due to their excessive use or misuse. Replacement of existing antibacterial agents with a novel and efficient alternative is the immediate demand to alleviate this problem. Graphene-based materials have been exquisitely studied because of their remarkable bactericidal activity on a wide range of bacteria. Graphene-based materials provide advantages of easy preparation, renewable, unique catalytic properties, and exceptional physical properties such as a large specific surface area and mechanical strength. Moreover, graphene has been utilized via functionalization with various nanomaterials such as metal ion/oxide NPs, polymers, enzymes, and photocatalytic materials leading to enhanced antibacterial activity. Recently, graphene has also been used as a carrier for controlled release of conventional antibiotics with improved therapeutic efficacy and reduced toxicity. Furthermore, various multicomponent materials have been developed by using graphene and different nanomaterials, which provided the higher antibacterial activity due to a synergetic effect. Overall, recent research advances in the field of fabrication of various novel graphene-based materials, their interaction with biomolecules, cytotoxicity, in vivo toxicity, and their applications in antibacterial activities, water purification, drug delivery, wound healing, and coating materials. Despite certain challenges, the antibacterial materials have become a necessary tool in modern medical science and several surgical operations cannot be executed without using them. Therefore, the urgent demand for developing new and improved antibacterial therapies to fight against infections has become crucial. It is hoped that the advances that have been made by the researchers in terms of understanding and developing graphene-based materials will prove fruitful in the near future. We prospect that the information provided in this review about the recent advances on the graphene-based materials such as the antibacterial agents will help scientists understand the ongoing developments, will excite novel ideas to conquer the associated challenges, and will assist the fabrication of new and improved antibacterial materials [55]. Again, in recent studies: Carbon Nano Tubes (CNTs) are allotropes of carbon with a cylindrical nanostructure. Nanotubes have been constructed with length-to-diameter ratio of up to 28,000,000:1, which is significantly larger than any other material. These cylindrical carbon molecules have novel properties that make them potentially useful in many applications in nanotechnology, electronics, optics and other fields of materials science, as well as potential uses in architectural fields. They exhibit extraordinary strength and unique electrical properties, and are efficient thermal conductors. Their final usage, however, may be limited by their potential toxicity and controlling their property changes in response to chemical treatment. Furthermore, CNTs are so small they might one day be used to target and destroy individual cancer cells (there are also very likely viruses and bacteria). By treating CNTs with certain proteins, scientists are developing a method to bind them specifically to cancerous cells. Once attached, the CNTs, which are excellent conductors of heat, could be exposed to infrared light shone through the patient's skin. The light would heat the CNTs to a temperature high enough to destroy the cancer cells while leaving surrounding tissue undamaged. While more research must be done, this method could offer a way to treat certain cancers without harming healthy tissue, a current drawback of treatments like chemotherapy [56].

V. HISTORY OF SIMULATION FOR NANOMEDICINE

Before you start this topic, a historical perspective is made: The first question is, What kind of computer are we going to use to simulate physics? Computer theory has been developed to a point where it realizes that it doesn't make any difference; when you get to a universal computer, it doesn't matter how it's manufactured, how it's actually made. Therefore, my question is, can physics be simulated by a universal computer? I would like to have the elements of this computer locally interconnected, and therefore sort of think about cellular automata as an example (but I don't want to force it). But I do want something involved with the locality of interaction. I would not like to think of a very enormous computer with arbitrary interconnections throughout the entire thing [57]. At any rate, it seems that the laws of physics Present no barrier to reducing the size of computers until bits are the size of atoms, and quantum behavior holds dominant sway [58]. This paved the way for quantum computers and quantum simulation. By the present day: As the search continues for useful applications of noisy intermediate scale quantum devices, variational simulations of fermionic systems remain one of the most promising directions [59]. Quantum simulation of chemistry and materials is predicted to be an important application for both near-term and fault-tolerant quantum devices [60]. These simulations are vital for many fields such as Physics, Chemistry, Nanomedicine and Materials Science. Such as, straining viruses of monolayer materials. The killing of viruses and bacteria by quantum dots. Virus and bacterial hygiene with ultraviolet beam syllabus in nanometer amplitude. Production of long-term batteries with new fermionic methods with nanomaterials, etc. They all seem to be a few applications that pave the way for new nanomedicine. Simulations such as in vivo (living) cell, brain activities, will perhaps contribute to one of the nanomedicine worlds of quantum computers.

VI. CONCLUSIONS

These studies have shown that the important steps of the future are that dimensional and topological materials will be very important. Solids can change their building of blocks. Monolayer graphene become massless Dirac fermions. Weyl and Majorana fermions, which makes such materials interesting for FETs such as topological quantum computers and other exotic but not absurd electronic (fermionic), anyonic (quasi-particle), weyltronic, spintronic, nanophotonic, plasmonic, monolayer (bilayer, multilayer), nanomaterial, nanostructure, nanoscale motion, nanomedicine devices. The enormous interest in Weyl and Majorana fermions goes beyond basic avocation though. There is huge workspace for future quantum information technology applications if devices can be made based on arrangement of new fermionic devices where a qubit (qudit, qumode, zeromode, etc.). Nanotechnology has gained great importance, especially in the detection and diagnosis of viruses after COVID-19. Research in quantum computing and nanotechnology have become increasingly multidisciplinary in order to contend with contemporaneous and up-to-date approaches that require the integration of knowledge and methods across a breadth of all scientific fields.

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