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Host IBS Center for Quantum Nanoscience at Ewha Womans University



Art Contest 2019 The World of Quantum



Special recognition to QNS outreach manager Sunny Kim. Thank you for your extraordinary leadership. COPYRIGHT © 2019 by Center for Quantum Nanoscience, Seoul, Korea







Director's Greeting

The pursuits of art and basic science have much in common. Both are creative, non-linear, and a unique ways to make a living. Both depend on patronage - collectors for artists and taxpayers for scientists - and require consistently communicating value that may not immediately be obvious. It's natural for artists and scientists to be allies.

Some have said that art is introspective - exploring consciousness - and science strives to understand external reality in the form of universal, indisputable truths. In the process of this contest QNS members did both. They learned about physics in new and various ways; both through educating artists about quantum nanoscience and through interpreting the works created by those same artists. Please take the time to read QNS student, Jinkyung Kim's excellent article (page 7) on the intersection of art and quantum nanoscience.

Sunny Kim, QNS' Outreach Manager, turned this art contest into far more than we dared to dream. She deserves full credit for the extraordinary level of engagement the art community made with the Center for Quantum Nanoscience. She devoted many hours to answering fundamental physics questions submitted by artists as they grappled to understand the mysteries of our physical world. The result was about 400 submissions to our art contest and such excellent pieces it was difficult for our panel of artists and physicists to select winners.

We offer our deepest thanks to the artistic community for embracing our research and our center. We hope this is the beginning of a long and compelling relationship.

Andreas Heinrich Director, Center for Quantum Nanoscience

Art Contest Subject

Quantum Nanoscience

Let us shrink down to the nanometer scale, then even further to enter the quantum world, where things that are impossible at our human scale become commonplace. Things can be in two places at once or pass through walls. Cats can be both alive and dead. Use your imagination to express the quantum world!

Outline

- Contest kick off talk on 'The World of Quantum' by QNS' 2nd year student, Jinkyung Kim. She gave an introduction for artists to the concepts of quantum nanoscience: 70 artists attended.
- First round: 396 artists submitted their artwork
- Final round: shortlist of 40 artworks competing
- Exhibition

Location: QNS, Research Cooperation Building at Ewha Womans University, Seoul, Korea Winners artwork: From September 2019 to September 2021 Final round artwork: From September to December 2019

> Open Lab Day for **The World of Quantum** Art Exhibition November 22, 2019 Kwin Womans University

QNS invites you to the art exhibition of quantum nanoscience. It is an collection of 44 artworks applied for a art contest "The World of Quantum". This event also has a lab tour and networking time with QNS researchers.

Event Schedule

What is Quantum Nanosciece?" talk by the QNS director Andreas Heinrich
QNS Lab tour: Experience the best low vibration facility in Korea.
Introduction to the artworks of the contest: Meet the winners.
Exhibition tour and networking with appetizers: Meet the QNS researchers

Prizes

QNS Director's Prize	3,000,000 KRW	One Prize
Second Prize	2,000,000 KRW	Two Prizes
Third Prize	1,000,000 KRW	Two Prizes

Website

qns.science/art

Host

IBS Center for Quantum Nanoscience at Ewha Womans University





Notes from the Evaluation Panel

For the Explorers of **Non-linear World**

The prosperity of commerce and science has brought about a great change in the overall philosophy and landscape of the arts, opening new dimensions of the world of creativity. Ever since science developed within human civilization, discussions on the intersection of art and science have never stopped as if the two areas are inseparable. After all, scientific research and advances have enormous influence on art while many artists engage with scientific subjects using diverse methods. The two seemingly incompatible territories have much in common in their understanding of the world. This is due to the fact that both scientific discoveries and artistic creations realize human imagination. Imagination and desire for beauty, matched with rationality, underlie scientific research and discoveries. At the same time, imagination is essential to fulfilling artistic sensibility and philosophy.

Nano, the prefix of nanoscience, comes from nanos, a Greek word meaning 'dwarf.' Nanoscience goes far beyond the academic concept born from Richard Feynman's brilliant vision. When combined with quantum, it explores the beginnings of all rationalities and irrationalities of the world and enables us to envision future civilization. The dot is one of fundamental, formative elements in art. It's where materialization of artistic creativity and imagination begins. The art contest 'The World of Quantum' is based on the encounter of nano and dot, science and art, and that of scientists and artists. Just as quantum nanoscience continuously explores the non-linear world to challenge the limits of existing science and technology, all entries convey their messages using their own language of formative arts - sometimes earnestly and sometimes experimentally. As the intersection of science and art represents the trend toward their interaction, related exhibitions often fail to go beyond declaring only that this interaction is appropriate. The World of Quantum, however, showed the artists' earnest reflections on the tiny unit of nano and the concepts of quantum. Both scientists and artists are explorers who do not fear going into uncharted territories. I hope the World of Quantum will help both areas progress further on their journey by serving as a platform to discover 'intangible' values.



Alice WOO Curator, Daejeon Museum of Art











Youngmi Shin (Artist) Julian Voss-Andreae (Artist) Jinkyung Kim (Researcher, QNS)

Evaluation Panel

- Seokyeong Kang (Professor, Ewha Womans University Art and Design)
- Alice Woo (Curator, Daejeon Museum of Art)
- Paul Thomas (Professor, University of New South Wales Art & Design)
- Andreas Heinrich (Director, QNS)

How Do Art and Quantum Nanoscience Connect?

Art and Science Toward the Same Direction

The subject of this contest is quantum nanoscience: the meeting of quantum and nanoscience. Yes, we know that quantum and nanoscience are both hard topics. Nonetheless, interestingly they both have connections to art! Here is an article that shows how the world of quantum and the history of art connect.

_ Jinkyung Kim (Doctoral Candidate, IBS Center for Quantum Nanoscience, Ewha Womans University)



Pablo Ruiz Picasso <Woman with Watch> (

<Woman with Watch> (1932) Picasso painted the front and sides of the woman to be visible at the same time. In the quantum world, two different states can be mixed (quantum superposition).

Duck-rabbit image



Many artists and philosophers like this image. Especially Wittgenstein wanted to show us that in our perception, we cannot see both a duck and a rabbit at the same time. We have no choice but to distinct each of the images (states) when we see this.

Seurat's Pointillism in Physics?

Did you know that light is highly important in art and science? First, let's look at art. This is especially true for artists like Claude Monet, Pierre Auguste Renoir, and other impressionist painters. They focused more on how human beings perceive natural colors, unlike the past perception that objects have their own colors. The most important factor for human beings to perceive nature is light, so impressionist painters pondered deeply about light and how to express nature according to light. They had come to realize that apples that were previously only represented in red can be expressed in terms of light angle and time, with completely different colors, such as brown or even black. This is one of the ways to capture how nature is seen by human beings.

As for science, during the same time period, the concept of light was changing in physics. Unlike in the past, where light was perceived only as a continuous wave (a kind of an electromagnetic wave), light was discovered to behave also like a particle with discrete energy. Therefore, light simultaneously has both wave and particle properties.

I am sure you all have heard of Einstein. He is the first person who used the expression "quantum" which means the discontinuity of light, in his photoelectric effect experiment.¹⁾ Through this experiment, he realized that light can be regarded as particles and called these particles "light quantum". The atom, the basic unit of matter, also consists of quantum which actually is both protons and electrons. Those particles are very small (nanoscale, 10⁻⁹m), so if you focus on those kinds of small particles then that would be considered in the realm of quantum nanoscience. In this scale of the world where quantum exists, even energy and space are "quantized", which means being discontinuous like quantum.

 Photoelectric effect (1921) is the phenomenon that electrons protrude from metal when light is applied to metal. Today it is used in various electronic products such as cameras and solar cells.

Does this remind you of anything?

This paradigm shift of light in both art and science suggests that the world seen by light in our eyes may in fact be discontinuous in some respects. And what does this mean? Consider the pointillism that is represented by Georges Seurat. By applying pointillism, he was able to quantize the world, which was unimaginable in the world of paintings in which there were only continuous brush strokes. In other words, Seurat expressed the world seen by light as discontinuous, which is actually true, proven by science.



Georges Seurat <A Sunday Afternoon on the Island of La Grande Jatte> (1884) Seurat expressed the world shown by the light with dots. Einstein proved that light can actually be seen as a discontinuous particle.



A Whole New World Explained by Quantum

Let's talk more about quantum, and how it can be explained by art. The concept of quantum itself is a new paradigm that collapses the existing world. The properties of quantum are also completely new. Unlike classical objects, quantum is not always fixed; things only exist based on probability. It is as well-known as Schrödinger's cat, which is a very famous analogy in quantum mechanics. This is similar to the duckrabbit image. Referring to this image, Wittgenstein said that we cannot see both a duck and a rabbit at the same time. It should be a duck or a rabbit, not both in our head. But what if this image is inside a box in the quantum world? Then the image is not completely a duck or a rabbit, it is simply 50% a duck and a rabbit simultaneously. This doesn't make sense at all in classical science. Even though we cannot see it, we can guess that they have both of those states. Thus, the image can exist as the image itself, not decidedly a duck or a rabbit. The quantum world allows us to see the world just as it is, without having to clearly define something.

In classical mechanics, 0 state and 1 state (like in digital information) cannot overlap. In quantum mechanics, however, these two states can exist simultaneously and this is called superposition. Superposition is general wave properties in both classical and quantum science, but if we think of waves as particles, then it makes sense only in quantum physics. This is similar to the way Picasso painted an object with a combined view, showing the front and side, unlike mainstream art where one object was viewed at one angle (perspective). This was a big turning point in how artists express an object, as important as quantum properties.

Another property of the quantum world is entanglement. Entanglement is a property in which two or more states are intertwined with each other. In classical physics, entanglement is impossible because the interaction between each object is low when the distance between them is very far. However, in **quantum** physics, the entangled states are maintained even if each quantum is very far apart. Therefore, if you know one of the two entangled states, we can know the state of the



Antony Gormley <Quantum Cloud> (1999)

Gormley was inspired by the world described by quantum mechanics. The structures in the artwork are intricately entangled. Also, since the boundaries between the artwork and the background are ambiguous, they are entangled and the background becomes part of the artwork.

other side at the same time. In other words, they are deeply connected to each other.

From the viewpoint of classical science, the characteristics of quantum are unrealistic, even impossible to imagine. However, after the discovery of quantum, it became a new reality beyond existing science. The word 'natural' usually means 'to fit to the context' or 'something continuous'. Then is the world not natural anymore? I think it is not.

On the Path to Find Answers

Paul Gauguin's famous work "Where Do We Come from? What are We? Where are We Going?" is about questions like 'what are we' and 'what is the world that makes us?'. These questions might be quite profound. But in some sense, one could say that life is always about finding our own identities and deeper meaning in the world. To answer these questions, quantum can give us a lot of insight. Since the world (and even ourselves!) consists of quantum, we can see the world in a completely different perspective compared to when we only focused on the classical world. The world is not determined by absolute truths anymore, but it depends on probability. We are living in a world that is filled with uncertainty. Moreover, the world is not continuous, in fact it is discrete even if we are looking at it in a continuous nature. The world is really not what it seems!

Both scientists and artists identify and express the world, just in different ways. Both of them come up with a lot of incredible ideas and sometimes it changes the whole world. They have many things in common. It is worthwhile to "entangle" both fields and seek their meaningful interaction. We hope you can find inspiration from these relationships to help ignite your creativity for your own work :)

Winners | QNS Director's Prize



JO Min Jeong One and Two Incense Two-channel video 2019



Artist's Statement

This work is an animation that combines filmed smoke with charcoal drawing. Drawings were obtained by repeatedly drawing and erasing images on a single piece of paper and have been embodied by a slowly burning incense, which was created by using a total of 176 scans.

Each of the two incenses in this work are made up of the same 176 drawing images. However, in the editing process with digital media, the order and time/space of the drawings are arranged differently and the layer of time is also subtly different between the two incenses. (What is interesting in the video editing process is that the location and space occupancy of each source represents time.) Therefore, the two incenses can be the same and different from each other simultaneously.

Everything consists of atoms. So do our bodies. However, according to quantum mechanics, which describes atoms' structure, the position and the quantity of motion (speed) of an electron cannot be known simultaneously. It is said that even the existence of an electron is not known until a measurement is made. This interesting fact arouses our imagination regarding the human existence. Is there really only one self that is immutable? Is not there any possibility of so many versions of me existing that are both the same as or different from the me here now? What is it about having contradictory states at the same time? Can we say that these states are real?

The incense in the work represents my existence that grows into something, proceeding towards a set end without knowing when and how it ignited. It is also a portrait of my imagination of the infinite number of cases in the universe.

Click to watch the video

Winners Second Prize

YOON Min Gee Untitled Variable size, Stones 2019

Artist's Statement

Untitled-2 is an installation work that makes the most of the space. Some of the most important work requirements are natural light, stone, an open door, and space. In the unclosed space with unbound trajectories, ordinary materials are placed in unordinary ways. This generates tension and the observers' movement and thinking is rapidly rearranged at the moment of recognizing the tension. The space reflecting the moving natural light and flow of time makes the objects' place temporary. Also the observer's perception changes as well. All these lead us to think of the simultaneous flow of all things that are not permanent and not perfect. At the same time, a tiny change in the flow of light or the observers' movement can trigger everything to be rearranged or redefined. This artistic potential always exists here along with the probability of all kinds of motion occurring at any moment.

I think an object may have three existential states - being 'real,' 'unreal' and 'potential,' a spatiotemporal state. The existence of a potential state (a state of probability) could be a point at which an object establishes its clearest identity. I assume that such a point could be a metaphor for a state of motion that precludes observation in quantum mechanics. This state is associated with many things: the possibility of existing and not existing at the same time, being defined but actually undefinable, the possibility to return to the object's essence at any time, the existence in itself, the intrinsic transcendence found at the object's unique point of existence, non-linguistic experiences of the space between materials and the fascination of the point remaining unspoken forever. Furthermore, I wondered what kind of art could combine an uncertain electron in an orbit (as stated by Heisenberg) and the state of quantum expressed in matrix mechanics with a real object and light (temporality) and space. I started by making and installing an object implying a tense state of motion and decided to talk about an object in the potential state of speech (or probable motility) and a point to respond to and observe it. In order to reveal objects at the subtle moment of utterance I set a range of conditions and then went through an adjustment process of removing, adding, or altering some elements before reaching the present outcome.

"Post-painting," a self-coined term, is basically "stripe" pattern-based computer graphics and installation. Leaving behind oil-painting which I worked on more than 10 years, I've been producing digital media works since

<Status Message from Nocturnal Vision: —Superposing Multiverse> references "coldness" of something like "power-off screen" while implying the process of digital image positioned in the place of painting. Hung down from the walls unto the floor (while they are mourning for painting), they set a flexible scene of "layers" in a space. The centralization of superposed "stripes" creates some sort of experience of anomia (inability to recall a name) and a mind space of non-meaning.

After all, the visuality of <Nocturnal Visions> attempts to represent "multiverse", the superposed possibilities in the world of quantum. They speak of the impossible visualization of multi-occuring parallel worlds, and contemplates pending messages of them.

Winners | Third Prize

Artist's Statement

There is a wide and large wooden plate with a surface smooth like glass. Several metal marbles appear in a row that produce tapping sounds and roll on the plate. In the middle of the plate is a hole big enough for a marble to pass through. The rolling marbles get closer to each other, change directions after crashing, or suddenly stopping, because of the spatial distortion and pulling force. They, however, eventually are pulled down toward the center. Under the hole is a rail on which the marbles are raised again onto the wooden plate. If landing successfully on the rail, the marbles keep rotating by repeating circular motions and chasing after one another.

Gaagaadonut, an artwork that looks like a huge toy,

contains the artists' imagination regarding the invisible world of quantum, or the microscopic world. Gaagaa is a Swahili word meaning "rolling and rumbling." If one interprets the result of the double-slit experiment from the perspective of the Copenhagen interpretation, an electron (light) is a wave before observation and becomes a particle at the moment of observing it. In other words, the condition of an electron exists as the superposition of probability before observing it, but at the instance of observation its quality is decided, no longer existing as a probability. The marble rolling on the plate is an analogy for the electron. Their circular motion implies the state of diffraction and interference, or the fact that the status of the electron was previously a wave. A device that slowly whirls and provides magnetism to the upper part and removes it is installed at the bottom of the plate. When the metal marbles

Maltakjin (LEE Hotak, LEE Ryeojin, CHO Yoonyoung) Gaagaadonut 100×100×100 cm, Mixed media 2019

locate exactly within the influence of the device, which is continuously rotating, the magnetism and the marbles capture each other. Like an electron becomes a particle when observed by the 'observer,' the marble halts its movement and is captured onto the surface for a while.

Although there has been a lot of criticism on the Copenhagen interpretation, which argues that observation affects the state of the object, the Copenhagen interpretation certainly led us to rethink about "observation" in science, and "seeing" in general. What is seeing? The visual art is also a visual science as it explores and comprehends the world through the act of "seeing" and expresses itself through the act of "being seen." We cannot help but ask ourselves whether we, as creators of art, have limited the concept of "seeing" only within a verbal frame. Niels Bohr writes that there

Click to watch the video

is no language to explain a state that is simultaneously a particle and a wave. It is that, when we bring the microscopic world into the macroscopic world of the human language, there is no way to explain it. We tried to erase the visual language methodology familiar to us, before starting this work. Experimenting to visualize the microscopic world and to verbalize images by connecting the elusive concept of quantum and artistic materials was similar to putting a hand in a dark box and groping around to find a way. When we assembled the mechanic device from parts, we encountered an uncanny thing, which looked like a musical instrument or an ancient script with strokes. The marbles' tapping sounds continuously hitting our ears soon composed a line and gave a tranquil sensation.

Winners | Third Prize

KIM Dasul Lightness of Perception

130×193 cm, Mixed Media (gesso and scaulpey on panel) 2019

Artist's Statement

Our view of the world is very limited. Humans depend on sight for more than 80 percent of their daily lives. Therefore, most of the ways in which people understand and view the world are determined by the act of seeing. But living in the 21st century, we now know

that there is more to the world than what meets the eye. With the advent of quantum mechanics, we have begun to recognize that our understanding of the world was erroneous and that there was another world where nothing was fixed. In a quantum world, what seems unimaginable in reality does happen, such as overlaps, entanglement, and disconnection. Though these are invisible to our eyes we actually see them all the while. In other words, there is an invisible world that is too small to detect but is part of our reality. That is the quantum world. My work began from the question: 'What if we can see the quantum world or if the characteristics of quantum are applied to the reality that we can perceive?' If a city were a new natural world, the skyscrapers would be split, merged, or transformed into completely different shapes in the quantum world. Worlds of infinite possibilities full of dynamic energy keep on moving constantly changing and influencing each other. This work captures a scene from the imaginary quantum-city. I hope it will help to better understand the quantum world as well as the visible world.

Donated to QNS

Artist's Statement

It is impossible to know the position and speed of an electron smaller than 1 nanometer (1nm), and its values change every time it is measured by light. I intended to express the quantum superposition status with both particle and wave indirectly through a person dancing the twist.

The Process

Step 1) Photoshoot and prints: As the music started, the middle-aged women at the Alumni Hall started to dance the twist freely together. I took multiple photos of my friend with a hat from the same spot. I printed all of the photographs onto paper.

Step 2) Making a temporary film: I cut out the images of the dancing people from the photographs. By sticking the cut photographs on a transparent plastic film, I made a sort of disposable negative film.

Step 3) The gum print process: I made an emulsion to use for the gum print process by mixing the gum solution, watercolor paint and photosensitizer at a fixed ratio. I sprayed the emulsion on BFK paper that is highly strong in the water. Now, the BFK paper had become sensitized paper. I placed one sheet of 'temporary film' from Step 2 on the dried BFK paper. After, it was be exposed to a strong light. I then developed the exposed BFK sheet of paper in a water tank for three hours and let it dry naturally. I repeated the gum print process several times. Through the processes in a dark room, n

LIM Myounghee *Twist* 120×69 cm, Digital Print on Paper (Photo Rag) 2017

temporary films made from the cut photographs were attached onto the BFK sheet of paper.

Step 4) The last digital print: The movements of my friend with the hat were overlapped n number of times on one sheet of BFK paper after the n times gum print process. As it was difficult to identify the gum particles on the finished gum print, it was scanned using a scanner, enlarged and went on a digital print.

Quantum Mechanical Interpretation

Although the Alumni Hall was a limited space, there was a calm and beautiful order during the dance, and there were no collisions. Photographs taken constantly during the dance were of those of discontinuous locations and movements. The dancer's traces were identified after making the artwork by repeating the gum print process onto one sheet of BFK paper with n pieces of temporary film. The most overlapped dancing area was white colored.

In the quantum world, when the particles are moving, the waves are not in one certain position but exist as patterns in various positions and change their shape as time goes by. The speed of the electron changes in the moment the location of the electron is identified through 'the uncertainty principle'. When the location of the quantum is changed every time it is measured, it should be estimated according to the probability, and 'quantum superposition' is a term to describe the overlapping state.

Final Round Artwork

KIM Young Jun , YUN Ji Won Everyday Life 42×54.9 cm, Printing 2019

JANG Inhee Hidden Moment 120×91 cm, Hand cut mirror, PET film, and acrylic on canvas 2018

LIM Sung Yeon Superposition State 112×112 cm, Acrylic on canvas 2017

LEE Sung Bok Semiosis Game - Dial 60×78 cm, Pigment print on paper 2019

HONG Junho Deconstruction of Idols; Art #015 100×130 cm, Pigment print (Taking a photo of a beam projection on crumpled paper) 2018

MOON Ki Jeon Quantum-Landscape-Anatomy 7 60×100 cm, Pencil on paper 2018

HONG Junho Deconstruction of Idols; Art #014 100×130 cm, Pigment print (Taking a photo of a beam projection on crumpled paper) 2018

KWON Hoe Chan Gesture Dot-Grid 80×100 cm, Oil on canvas 2018

LIM Chanmi Stare Fixedly at a Flower 1 50×50 cm, Digital print 2019

LEE Yunjin Movement in the Silence 74×95 cm, Indian ink on Korean traditional paper 2011

LEE Youngho Interpèrte 131×163 cm, Mixed media with Korean Hanji paper on canvas 2018

KANG Eun Jin The World of Quantum 65×80 cm, Woodcut printing & Korean painting 2019

LEE Chaerin Believed Survivors 91×116.8 cm, Mixed media on Korean traditional paper 2019

KIM Woo Collision #13, Blue Collision #14, Purple Collsion #15, Green Collsion #16, Orange 53x41 cm each, Acrylic and oil on canvas 2019

HAN Jiun Come Across 1 91×91 cm, Acrylic on jangji (Korean paper) 2018

HAN Jiun Come Across 2 95×67.1 cm, Acrylic on jangji (Korean paper) 2015

OH Ji Hye O(zero) Waves 390×162 cm, Acrylic on canvas 2017-2018

PARK Si-Young The Theory of Light and Matter 91×91 cm, Oil Painting 2019

LEE Hyunmin *Illusion 1* 160×131 cm, Korean paper with multi pigment 2017

LEE Hyunmin Illusion 2 22×27.3 cm, Korean paper with multi pigment 2017

LEE Hyunmin Illusion 2-1 22×27.3 cm, Korean paper with multi pigment 2017

JI Hanshin *Volume* 29.7×21 cm, Houdini, illustrator 2019

SONG chaerim *Transparentness* 30×30×33 cm, Acrylic, LED, Formax 2018

KANG Sukho Trans-Society #11[Book] 42.7×37×17.2 cm, Book, wood, glass, acrylic 2018

YOU Seung Hee Uncertainty 30.5×34×36 cm, Mixed materials 2019

Y00 Jooyeon Orbital Cake 20×20×6 cm, Coloring on plaster and clay 2019

Ray PARK The Coexistence – Banana 20×10×25 cm, Emulsion, Acrylic 2013

Videos

KIM Minji, KIM Subin, BAE Soyoung, Image of Quantum, Video, 2019

YANG Lora, Circulation: Wave and Negentropy, Video, 2019

JANG Mingyeong, The Sound of Dust, Video, 2019

LEE Chaerin, A Trip, Video, 2019

Click to watch the videos

KIM Sung IL, Quantum Camera, Video, 2019

SON Mikyung, Gold, Video, 2016

LEE Jonghwan, Hole, Video installation, 2019

LEE Hyunwoo, KIM Gryuri, PARK kangsol, LEE Yesong, Our Cosmos, Video, 2019