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Cat, Retro-Causality and Emotion

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Abstract

The Schrödinger's cat phenomenon is a strange consequence of the superposition of quantum states. The necessity for unobserved quantum systems, under certain circumstances, to exist simultaneously in several mutually exclusive states could be considered as the most shocking discovery of physics during the last one hundred years. The analysis of von Neumann and Wigner resulted in the conclusion that human consciousness is causing the collapse of the wave function, and thus forcing the universe to choose among available alternatives.

To avoid this conclusion, several other interpretations have been developed, like Everett's splitting of the universe, or Bohm's pilot wave hypothesis. All of them suffer from new kinds of difficulties, and they all introduce new elements that cannot be verified.

In most of the interpretations, the choice of final state also includes a choice of one among several possible histories, so the observation influences the past as well as the future.

This indicates that time might not proceed in any specific direction until an observation is made. Consequently, collapses of wave functions might establish the real arrow of time.

Walker has made attempts at using theories of quantum tunnelling among synapses in the brain, in order to find the extent to which emotions and wishes are able to influence the outcome of the wave function collapse. The results appear to be to an order of magnitude similar to those found in studies in which subjects have tried to tell the outcome of random events.

As Wigner pointed out, we never observe more than one out of several possible results of an observation. So how does the universe make its choice on which outcome will turn into reality? Are we able to influence the choice? My own personal experience weakly indicates that my emotions in some rare cases have been able to influence the choice. Or could it be that my emotions have been influenced by the future outcome?

With very few exceptions, quantum mechanical wave functions have regions of high probability amplitude, but also regions with very low probability amplitudes. The existence of such regions of low probability cause phenomena like alpha decay, in which alpha particles inside the nucleus tunnel through the coulomb barrier to a low probability state of being free particles.

Most of the miracles told in the Bible could be described in terms of states with extremely low, but non-zero, probabilities, chosen by the universe in the right moment. According to the Bible the extremely low probability may be changed to reality by faith, hence by a kind of emotion.

If this is a correct interpretation of miracles, there does not appear to be any limit to the ability for emotions to shape the world.

Keywords
Consciousness, Schrödinger's cat, retrocausality, wave function collapse, tunnelling, coulomb barrier, superposition, miracle, phase velocity, group velocity, stationary state, multi-dimensional time.

Introduction

The Schrödinger's cat phenomenon is a strange consequence of the superposition of quantum states. The necessity for unobserved quantum systems, under certain circumstances, to exist simultaneously in several mutually exclusive states could be considered as the most shocking discovery of physics during the last one hundred years. The analysis of von Neumann (1955) and Wigner (1970) resulted in the conclusion that human consciousness causes the collapse of the wave function, and thus forces the universe to choose among available alternatives.

This conclusion was more or less inevitable from the Copenhagen interpretation of Quantum Mechanics (QM). To avoid this conclusion, several other interpretations have been developed, like Everett's (1957) splitting of the universe, or Bohm's (1952) pilot wave hypothesis. All of them suffer from other kinds of difficulties, and they all introduce new elements that cannot be verified, e.g. the existence of all possible outcomes simultaneously, with all but one unobservable.

In most of the interpretations, the choice of final state also includes a choice of one among several possible histories, so the observation influences the past as well as the future.

Imaginary time

It is sometimes stated that all (observable) information in a system is stored in the wave function. Although not exactly correct, it is not far from reality. When quantum mechanics and relativity confront one another, problems appear. In relativity, the speed of light (normally) is an absolute limit, while quantum mechanics requires some properties to propagate faster than the speed of light, possibly even at infinite velocity.

The Hellmann-Feynman (Hellmann1937, Feynman 1939) theorem brings some hints for understanding wave-particle duality. The theorem states that the energy of a system, e.g. a molecule, has exactly the same value as it would have if the electrons were smeared out according to the probability density of the wave function, and the attraction were purely electrostatic. This would be the case if the very small electrons were moving rapidly between different locations in a more or less irregular way. To do so, the electron would have to move faster than the speed of light, as some electronic states have very short life times. Alternatively, all the distributed charge would have to move instantaneously to one location at a wave function collapse.

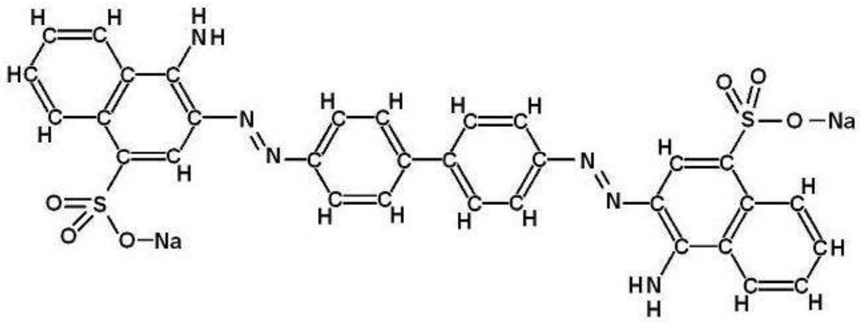

Fig 1: Congo-blue, a dye molecule. In the molecule, some molecular orbitals stretch across the entire molecule, which means that the probability densities of some electron pairs are distributed across a considerable volume.

In a dye molecule like Congo-blue, each π-orbital covers the entire molecule, as well as a substantial volume surrounding it, some 35x10x5 Å3. Even at the speed of light an electron would not be able to span the orbital during the life time (a few nanoseconds) of an excited state. In molecules, only stationary states (orbitals) are allowed except for short moments during which the molecule is interacting with the photon field (in the absorption or emission of light).

It can be argued that the electrons are "moving" at infinite speed in order to span the orbital. From one point of view, each electron has to be fully present in each location for it to keep properties like charge or mass. According to quantum electrodynamics, the electric field around an electron is established by photons being created and annihilated by a (point-) source. This would lead to infinite electron mass, as the size of the electron appears to be zero. The field itself remains finite due to vacuum polarization, a counterfield caused by virtual photons created by the vacuum. This means that the electron mass grows more slowly as the electron radius tends towards zero. Nevertheless, the mass is divergent (tends to infinity), and to avoid that, renormalization is used. In this process, the (infinite) mass of the excluded vacuum is subtracted from the electron mass. For all this to work in every moment, the entire electron with real and virtual photons has to be present everywhere in the molecular orbital. This could be achieved by the entire electron appearing in one location, staying there for a short moment, and then instantaneously jumping to another location. As mentioned above, this has to take place at superluminal mean speeds. As the orbital is a continuous function, it looks probable that the speed actually is infinite (as seen in ordinary time).

From another point of view, one has the fact that a molecular orbital is a stationary state. This means that the wave function does not change with time. That is not exactly true, as real and imaginary parts of the wave function actually are oscillating or rotating. The changes are syncronized to make the absolute value of the wave function stationary.

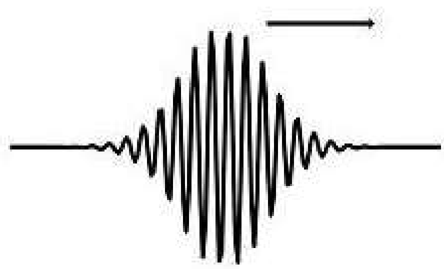

Fig 2: A wave packet moving to the right. Individual waves are created to the left, move through the package (phase velocity), and disappear to the right. The package itself moves more slowly (group velocity).

In a non-stationary wave packet, there are two kinds of velocity, group velocity and phase velocity. The phase velocity is always larger than the group velocity, which means that waves are created in the rear end of the wave package, and disappear at the front end. This disappearance is caused by destructive interference of waves everywhere except within the packet. The two velocities obey the de Broglie relation

$$v_{group}\, v_{phase} = c^2 \tag{1}$$

The group velocity is the one with which an object, e.g. a particle, is moving. Matter is normally not able to move faster than light. Although relativity does not exclude the possibility of particles (tachyons) moving at superluminal speeds, this has not been observed. Consequently, at least for all normal matter, the group velocity is less than c. Thus, the phase velocity normally has to be larger than c. As the group velocity tends towards zero, the phase velocity tends towards infinity. Consequently, for a stationary wave packet, the phase velocity is infinite. This means that an orbital is spanned instantaneously, and thus the electron is everywhere at all times, corresponding to infinite speed. And at each location, it has to build the entire field of photons and vacuum polarization. A second theorem by Feynman (1948) states that the evolution of the wave function is identical to the result from *all* possible trajectories connecting the initial and final state. This view supports the idea that the tiny electron moves at superluminal speed (or equivalent) between different parts of the wave function. One obvious possibility would be that time does not proceed in any specific direction between observations.

This view is supported by the shape of the wave equation. In the non-relativistic case, the Schrödinger equation may be used. Generally time is considered to be topologically one-dimensional. Assuming time to be complex-valued (two-dimensional), an interesting property emerges, if the Schrödinger equation is written in imaginary time. Then it will look like

$$\frac{\partial \Psi}{\partial(-it)} = \frac{-???}{2m} \Delta \Psi + \frac{-v}{???} \Psi \tag{2}$$

This equation is formally identical to the diffusion equation

$$\frac{\partial C}{\partial(t)} = -D \Delta C + rC \tag{3}$$

Concentration changes in a solution result from random movements and chemical reactions among molecules. Similarly, development of the wave function can be looked upon as a result of random movements of particle(s) in (negative) imaginary time (actually, the movement of two particles, one giving Ψ, and the other its complex conjugate Ψ^*.) Such random motions would give rise to the wave function being spanned by the particles following all Feynman's trajectories. But it requires influences outside the light cone, or some other strange behaviour.

Mach-Zehnder interferometer and retro causality

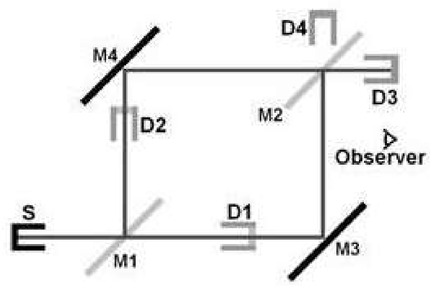

Fig 3: Mach-Zehnder interferometer. A photon from the source S is split at the semi-transparent mirror M1. It then follows two paths, via mirror M3, and M4, to be rejoined at the mirror M2. If both of the detectors D1 and D2 are switched off, all photons sent by S appear in detector D3. If either one of D1 or D2 is active, photons appear in detector D3 as well as D4.

The wave function of a cat, a box, and a deadly mechanism is of course extremely complicated, so the Mach-Zehnder interferometer will be used as an analogue. In such a device, photons from a source (S) are "split" by a semi-transparent mirror (M1) and travel along two paths, after which they are recombined by another mirror (M2). Interference causes all photons to appear in one detector only (D3). Here we will discuss a modification with two more detectors that may be activated after a photon has passed M1. If any detector is activated, the interference is destroyed, and photons will be found in both D3 and D4. Furthermore, no photon will be found in more than one of the detectors D1 and D2, meaning either that information will have to be transferred at superluminal velocity, or that the photon decides at M1 what to do in all kinds of possible future situations. The second alternative is less probable, as it contradicts the Hellmann-Feynman theorem. Even with such a simple device, the wave function is very complex during interactions. After the interactions, all non-diagonal terms will be zero, so the total wave function may be found by summing products of functions representing final states.

$$\begin{aligned} \Psi_{before-obs} = c1\psi_{D1-off}\psi_{D2-off}\psi_{D3-detect}\psi_{D4-no-detect} \\ +c2\psi_{D1-on-no-detect}\psi_{D2-off}\psi_{D3-detect}\psi_{D4-no-detect} \\ +c3\psi_{D1-on-no-detect}\psi_{D2-off}\psi_{D3-no-detect}\psi_{D4-detect} \\ +c4\psi_{D1-on-detect}\psi_{D2-off}\psi_{D3-no-detect}\psi_{D4-no-detect} + \dots \end{aligned} \tag{4}$$

Some terms, like $\psi_{D1-on-detect}\psi_{D2-off}\psi_{D3-detect}\psi D4 - detect$, represent impossible states, so the corresponding coefficient is zero. At observation, collapse to a unique result takes place, e.g.

$$\begin{aligned} \Psi_{before-obs} \rightarrow \Psi_{after-obs} = c\psi_{D1-on-no-detect} \\ \psi_{D2-off}\psi_{D3-no-detect}\psi_{D4-detect} \end{aligned} \tag{5}$$

Figure 4 shows what this looks like in a regular space time diagram. The wave packet splits in two, each propagating in time. The detectors could be non-destructive (e.g. polarizers), and the observation also could be delayed until the photon has reached D3-D4, or later. This does not change anything. At mirror M2 (figure 3), the photon will have information concerning states of D1 and D2 at time t4, and interference will not happen if one detector was active. Thus, if one detector e.g. D1 is active and fires, the photon chose that route. If it does not fire, the photon chose the other route. In both cases, the route will be known, and then interference is impossible.

If, on the other hand, the motion is random (as suggested above), the diagram looks different. For a photon, space and time cannot be separated, so random motion in space is equivalent to random motion in real time, all of

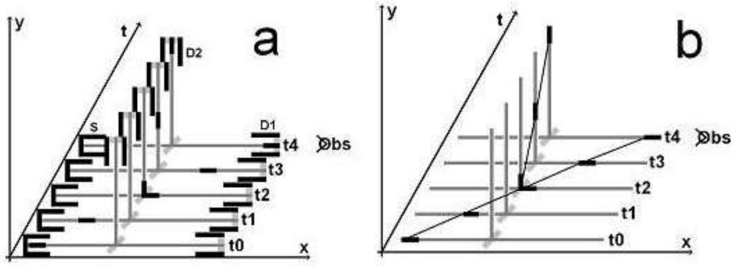

Fig 4: Space-time diagrams showing propagation of a single photon as seen in real time. Equipment shown (a) and hidden (b). The photon is represented by a thick black line segment.

which takes place in imaginary time. In Figure 5, the photon moves mostly forwards in time up to t4, where it meets the detector D1. Then it happens to move backwards and, choosing the other route at M1, reaches D2, again at real time t4.

After real time t4, the observation takes place. Then, one of the imaginary events is chosen, perhaps randomly by the universe or, perhaps, with the choice being influenced by the observer. After the observation, the past is irreversibly chosen.

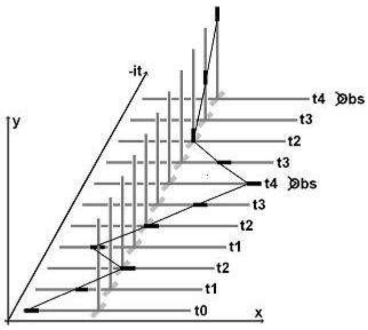

Fig 5: Part of a space-time diagram with random motion of a pseudo particle in imaginary and real time.

Choice among QM alternatives

As Wigner pointed out, we never observe more than one out of several possible results of an observation. So how does the universe make its choice on which outcome will turn into reality? Since processes in imaginary time result in several events at the same real time, there is a necessity for a specific choice to be taken. Are we able to influence the choice? With our imagination, we are able to see possible results, and often we wish one specific result to become real.

Each alternative gives a more or less different outcome. In some way, no alternative is real until a choice has been made. This is similar to imagination. We are able to imagine different futures, and then we decide which we wish to be real, and act accordingly. So, in some way, we appear able to influence the possible firing of synapses in our brains, to fulfil our wishes. It cannot be excluded that the same kind of ability extends to external systems as well. Our own wave function is a part of the universal one, and before collapse, all possibilities are open. We might be able to wish a certain outcome to become chosen. There is weak evidence that this may be the case.

It has been reported (Nelson and Bancel 2011), that wishes by persons have been able to influence the outcome of random events. One also can see that the fatalities of accidents often are far less than one would statistically expect. A well-known example is the September 11, 2001 terror attack. Although four planes were crashed, and both towers collapsed, only about 3400 persons were killed. One would have expected 7000 - 12000 fatalities. And the doomed flights had cabin occupation far below the expected, 35, 25, 23, and 16 percent respectively. One has to remember that it was a weekday (Tuesday), and morning flights. Such flights normally are quite crowded with cabin occupation of 80 percent or more. Here, six mutually independent events caused the low number. This could be pure chance, but the probability is far less than 1 per million. For some reason, people were not where they normally would have been. And people in the north tower emotionally distrusted the announcements on loudspeakers that there was no danger, and that all work should continue as usual in that building. So their emotions caused them to evacuate. Furthermore, passengers tended to avoid the doomed flights, some even through trivial misunderstandings.

People's imagined and wished futures might have influenced their choice: a dead person cannot go for vacation next week. Was this influenced by the quantum choice of alternatives? Is it an example of retro-causality?

World trade Center	Estimated staff on duty	Expected fatalities	Expected fluctuation	Real fatalities	Std deviations
North tower	50 percent	1818	43	868 (estimate)	22
South tower	50 percent	3637	60	1736(estimate)	32
Sum of towers	50 percent	5455	74	2605	38
Rescue personel etc.		403	0	403	
Flights	Aircraft type				
AA 11	Boeing 767	174	13	76	7.5
UA 175	Boeing 767	174	13	51	9.5
AA 77	Boeing 757	170	13	53	9.0
UA 93	Boeing 757	170	13	33	10.5

Fig 6: Fatalities in September 11, 2001 terror attacks.

Tunnelling among synapses

Walker (2000) has made attempts at using theories of quantum tunnelling among synapses in the brain to find the frequency by which emotions and wishes are able to influence the outcome of the wave function collapse. The results appear, to an order of magnitude, to be similar to those found in studies in which subjects have tried to tell the outcome of random events.

From a Biblical point of view, this is evident. An example is given by Jesus (Mark 11:23-24), in saying that if we let our wishes be known to God, and believe that He will grant them, this will happen. My own personal experience weakly indicates that to be correct. Decades ago, my wife had a disease (then unknown), sometimes causing severe pain in her stomach. To comfort her, I used to keep hugging her for extended times. A few times, I felt that I should pray for her at such occasions. When following that emotion, I could feel some kind of power leaving through my hands. I did not move mean-while, and not say any words loud. Nevertheless, she asked: "Did you pray? I felt power enter me, and the pain disappeared." On the other hand, it could have been imagination and coincidence only. When she had an incurable cancer in 2012, I never had the feeling that I should pray for her healing, and she died a few months after the diagnosis.

Collapse and miracles

It is generally assumed that QM may be used to describe microscopic systems, whilst macroscopic ones are almost perfectly described by classical physics. This is wrong! Whenever a phenomenon is highly non-linear, QM uncertainties may have major impacts on the outcomes. This is the case with earthquakes and hurricanes. According to Walker (2000: 269-270), even such a simple device as a dice has to be treated by QM. If it bounces some 50 times, the outcome is totally independent of initial conditions.

With very few exceptions, quantum mechanical wave functions have regions of high probability amplitude, but also regions with very low amplitudes. A 1s electron in a hydrogen atom has a probability density function given by

$$\Psi_{1s}^2 = \frac{1}{\sqrt{\pi a_0^3}} e^{\frac{-2r}{a_0}} \tag{6}$$

Here, a_0 is the Bohr radius. This function has non-zero values at all distances. An electron belonging to a certain hydrogen atom might be found far from the nucleus if its position is measured. In numerical QM calculations, one normally makes use of a cut-off, which means that outcomes with extremely low probabilities are neglected. This does not influence properties like energies, charge densities etc. In spite of that, the low probability tails are real, and very important in some situations.

An example is the alpha decay of Uranium-238. An alpha particle formed in the nucleus may, with extremely low probability, be found outside the Coulomb barrier, due to the tail of the wave function. For an individual nucleus, this may happen during one femtosecond in a time span of 4.5 billion years. Nevertheless, such processes are essential for life on Earth.

Most of the miracles told in the Bible could be described in terms of states with extremely low, but non-zero probabilities, chosen at the right moment. According to the Bible the extremely low probability may be changed to reality by faith, thus by a kind of emotion. Examples thereof are the virgin Mary being pregnant, Jesus' walking on water, or even resurrection from death. None of these is impossible: they are merely events of probability small enough to be considered practically impossible. For a human in the right emotional state, it might be a question of seeing the desired outcome, and choosing the appropriate value of the imaginary time for that outcome to become real.

Conclusion

Considering time to be complex-valued (two-dimensional), with real time propagating randomly between observation events, makes it possible for particles to span the wave function and fulfil requirements of quantum mechanics, including the possibility of Schrödinger's cat being simultaneously dead and alive, and for the point-like electron to be everywhere simultaneously. At observation, one out of several possibilities is chosen, and consequently one out of several histories is chosen as well. Superluminal velocities appear in real time, but are merely illusions, analogous to the possibility of making a shadow move faster than light.

Some of the possible outcomes from the wave function collapse have extremely low probabilities. This, however, does not prevent them from taking place and being important, as seen from the decay of Uranium-238. Miracles generally belong to that category of events with extremely low, but non-zero probabilities. There is evidence that wishes and emotions may (weakly) influence this choice. It is also claimed that faith gives the choice of such outcomes a higher probability. Perhaps the human mind is able to modify the outcome slightly, while Divine intervention is required for a specific result to be chosen with certainty. If this is a correct interpretation of miracles, there does not appear to be any limit to the ability of emotions to shape the world.

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Enn Kasak qualified from the University of Tartu in 1981 as theoretical physicist (specialization in astrophysics). In 1981-1995, he did research on the physics of galaxies and cosmology at Tartu Observatory. He acquired a Ph.D. in astrophysics in 1990. Kasak worked as the director of Võro Institute from 1995-1997, helping create the orthography and grammar for his native language – Võro. From 1998-2007 he was an associate professor in the University of Tallinn and the Institute of Law. Initially, he studied the early history of science and pseudo-science in Ancient Mesopotamia, later he devoted himself to the problems of logic and argumentation. Since 2007, he has been an associate professor of the methodology of science at the University of Tartu. In 2014 the University of Tartu Press published his book on logic (in Estonian). Lately, he has also worked on questions of reality, religiosity of science, and scientific stupidity.

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Javier Leach studied Philosophy at the Facultad San Francisco de Borja (Barcelona) from 1961-65. From 1965-1970 he studied Mathematics at Universidad de Zaragoza. From 1970-1973 he studied Theology at the Philosophisch-theologische Hochschule Sankt Georgen in Frankfurt am Main (Germany). He took a Doctorate in Mathematics in 1977. From 1987 he was Professor at the Universidad Complutense in the area of Computer Languages and Systems. Since 2012 he has been retired Professor and Honorary Collaborator in the area of Computer Languages and Systems. His research interests include: Automatic demonstration of Theorems through the Use of the Computer, Automatic Deduction Systems based on Tableaux, Declarative Programming with Constraints, Hereditary Harrop Formulas, and Science and Theology.

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Mark Pretorius has been a senior academic at the South African Theological Seminary (SATS) for the last 4 years, having served before that as its senior assessor since his appointment in 2002. He holds a Ph.D from the University of Pretoria (UP) in the discipline of systematic theology and ethics. He is also an extraordinary lecturer at UP, and a lecturer in ethics at the University of South Africa (UNISA). He has approximately 13 years full-time teaching experience in the discipline of theology, specifically in systematic theology. He also has a strong interest in the discipline of science and theology, and oversees the SATS M.Th. in science and theology. So far, he has published 12 scientific and 4 popular articles. He has also published 4 books, and co-authored three.

Bill Shoemaker is a neuroscientist who received his Ph.D. from the Massachusetts Institute of Technology (MIT) and has held positions at the National Institute of Mental Health, the Salk Institute in La Jolla, CA, and currently at the University of Connecticut Health Center in Farmington, CT. He is in the Psychiatry faculty, where he teaches residents and medical students, and in the Neuroscience Graduate Program. He has authored more than 100 scientific research publications. Recently, he has been writing concerning the interface between neuroscience and religion.

John A. Teske is Professor of Psychology at Elizabethtown College, Elizabethtown, Pennsylvania, USA. He is a past President of the Institute on Religion in an Age of Science (IRAS), and has published regularly in Zygon: Journal of Religion and Science, including "From Embodied to Extended Cognition" (2013), and "Neuromythology" (2006). He is also on the Joint Publication Board. He was voted an Academic Fellow of IRAS in 2010, and a member of the Institute for the Study of Science and Religion (ISSR) in 2013. He was co-organizer for an IRAS Conference on "The Mythic Reality of the Autonomous Individual" in 2009, and will be again for "More Than We Can Know: Worldviews, Lifeways, and the Limits of Science" in 2016.

Berge J. Traboulsi is an Associate professor of History, Religion, and Intercultural Studies at Haigazian University, Lebanon. His current research interests are in the following areas: Religions, Human Rights, Citizenship, Applied Ethics, Leadership and Change Management, and Modern Church Challenges. He has participated in several local, regional and international conferences and presented papers on intercultural, interreligious, and social issues.

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