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New architectural ideas require new structural engineering

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Abstract

Human society evolves through interconnected relationships and is historically shaped by cosmological views that influenced culture and architecture. Religious cosmologies dominated until the 16th–17th centuries, when Galileo and Descartes introduced first scientific paradigms. Newtonian physics framed the 18th–19th centuries, relativity defined the 20th, and the 21st is engaging with quantum and holistic perspectives. These shifts, alongside technological change, suggest a transition toward a more integrated worldview visible in architecture. Architecture mirrors prevailing cosmologies: modernism reflected Newtonian rationalism, postmodernism expressed relativistic plurality, and quantum cosmology—stressing interconnectivity and emergence—inspires parametric and quantum design. This affects aesthetics, construction methods and the architect–engineer relation. Today, holistic approaches encourage collaboration, aligning with broader scientific convergence. Architect and engineer now share responsibility for creating adaptive, ecological, systemic architecture, oriented toward emergent biological paradigms, thus reshaping space, structure, function, and experience.

Keywords: Architecture, Quantum physics, Convergence, Transdisciplinarity, Space

Introduction

Over the past three centuries, society has progressively shifted from religious frameworks to scientific paradigms in seeking moral and existential answers. Architecture, inherently multidisciplinary, reflects paradigms from the humanities, sciences, arts, and cultural and social dynamics - shaped in turn by users' values, needs, and aspirations. Nowadays, these elements are profoundly impacted by prevailing cosmological and scientific worldviews.

Historically, architecture mirrors its era: "1. It is built into the space and time of its era. 2. It is built of the materials and methods of constructions of its era. 3. It is built out of the structures of consciousness of the people of its era. 4. It is built in the socio-cultural context of its era." (Lobell, 2003). These factors are interdependent and reveal architecture as a synthesis of broader societal constructs.

The transfer of information between sciences and architecture is usually realized with a delay of a few generations.

The mechanistic worldview born in the 17th century laid the foundation for 20th-century modernist architecture. Figures like Walter Gropius, Mies van der Rohe and Le Corbusier embodied this perspective, emphasizing industrialization, efficiency, and functionality. Defined as machines for living, their designs - such as Le Corbusier's *Unité d'habitation* and Mies's *S.R. Crown Hall* - highlight structure and material clarity, manifesting a vision of buildings as rational, object-based constructs mirroring the mechanical interpretation of the universe.

This mechanistic paradigm was succeeded in physics by Einstein's theory of relativity, influencing architectural thought through works like Sigfried Giedion's *Space, Time and Architecture* and Bruno Zevi's *Sapere di vedere l'architettura*. Relativism's core principle - that truth is subjective - encouraged architecture to explore spatial ambiguity, contextual responsiveness, and multi-perspective perception. Postmodernism embraced this, fostering architecture as a complex message system that integrates science and humanities.

Notable examples include the 21st Century Museum of Contemporary Art in Kanazawa, Japan, by SANAA, where spatial fluidity and opacity guide user experience, and the Beijing National Stadium ("Bird's Nest") by Herzog & de Meuron, where structural expression blurs into architecture itself. These works illustrate the architectural embodiment of relativistic and post-structural thought.

But contemporary architecture now evolves under yet newer paradigms, shaped by advancing scientific and philosophical frontiers.

New architectural ideas

From the perspective of science, culture, and gnoseology - including architectural thought - current societal developments indicate a profound ontological shift. This transformation stems from radical changes in scientific cosmology over the past century, initiated by quantum physics and reinforced by advances across multiple disciplines. Emerging transdisciplinary frameworks such as systems theory, chaos theory and emergence theory, part of the complexity science, have restructured broad domains of knowledge, offering new paradigms for understanding both micro- and macro-cosmic phenomena.

While modernist and postmodernist architectural periods were shaped largely by classical and relativistic physics, contemporary thought is now increasingly informed by the epistemological and ontological implications of quantum mechanics. Unlike classical physics, quantum theory reveals a probabilistic and relational structure of reality. Subatomic particles exist not as isolated entities but as probability waves, their states dependent on the observer's interaction. The observer effect challenges Cartesian dualism and the traditional dichotomy between subject and object, replacing it with an interdependent, participatory view of reality.

Fig. 1 Corresponding ideas in mechanistic and quantum cosmologies

[basis of mechanistic cosmology]	[basis of quantum cosmology]
[singularity] (particle)	[duality] (wave / corpuscle)
[the observer is dissociated from the phenomena around]	[the observer is a part of the phenomena around]
[plurality] (of objects)	[unity]
[singular mechanical interactions]	[interdependence][interrelation]
[patterns based of immutable laws]	[lack of causality] [lack of individual model]
[dynamics] (of particles)	[dynamics] (of waves)
[locality]	[non-locality]

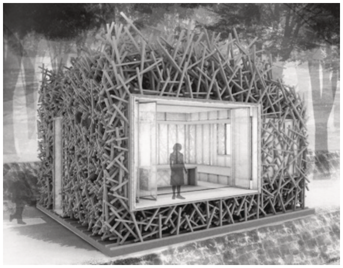
Figure 1 shows a comparison between principles underlying mechanistic and quantum scientific cosmologies. We can easily see that the two sets of paradigms are basically diametrically opposed, which indicates the transfiguring impact of a quantum cosmology when adopted by a materialistic and functionalist society.

This conceptual shift has implications beyond the microcosm. Recent integrative theories spanning quantum physics, neuroscience, and psychology propose a tripartite universe composed of space-time, matter, and consciousness - each with distinct degrees of freedom (Smythies, 2003). Experiments confirm the transformability of particles into waves and waves into energy and vice versa, reinforcing the notion of a unified, dynamic cosmos composed of relational processes rather than isolated substances.

Consequently, as scientific cosmology evolves, the foundational value systems of human society - and by extension, architecture - are transitioning away from the materialist paradigm toward one that embraces quantum and biological principles. This paradigm shift, still unfolding, signals a reconceptualization of architectural discourse, grounded in interconnectivity, dynamism, and ontological complexity.

The implications of quantum theory for architecture and urbanism are being actively explored by architects such as Ayssar Arida and Kas Oosterhuis. These emerging paradigms influence a new generation of design strategies rooted in complexity, interconnectivity, and nonlinearity. One example is *Algorithmic Space* (fig.2), developed by a Japanese team led by Shohei Matsukawa. This structure exemplifies a "quantum" structure - its resilience arises from the dense interconnection of numerous simple non-structural elements, yet its internal logic remains opaque without external analysis, reflecting the probabilistic and indeterminate nature of quantum systems.

Similarly, the *iVan Laboratory* (fig.3), designed by Georg Flachbart and Ivan Redi, manifests the superposition principle by merging physical and digital realms. As the authors describe, iVan represents a quantum object in which real (offline) and virtual (online) spaces coexist simultaneously, embodying quantum logic (1 and 0 at once) rather than the binary exclusions of classical physics (Flachbart & Redi in Oosterhuis, 2011). Such examples suggest a growing architectural discourse informed by quantum mechanics, where space, structure, and function transcend classical linear determinism.



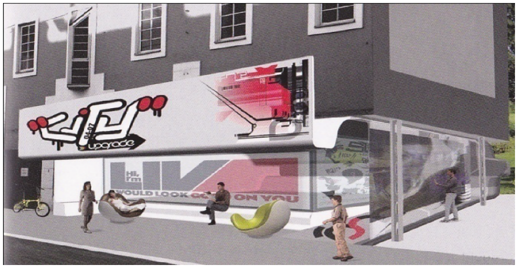


Fig. 2 Algorithmic Space

Fig. 3 Ivan laboratory

In the early 21st century, quantum physics offers the most comprehensive framework for understanding the universe. Its principles -either directly through their theoretical implications or indirectly via interdisciplinary diffusion - are increasingly integrated into architectural discourse. This integration fosters transfigurative concepts, forms and meanings aligned with the societal transition from materialist and quantitative to more qualitative, spiritual value systems.

Contrasting with modernist and postmodernist approaches, where structure is treated as an independent architectural element, quantum-informed and avant-garde postmodern architecture dissolve the boundary between structure and form. *Algorithmic Space*, for instance, exemplifies a paradigm in which the structural logic is inseparable from the architectural identity.

Such fusion signifies a conceptual shift not only in design practice but also in structural engineering. As quantum principles reshape architectural thinking, they likewise prompt a redefinition of engineering paradigms to accommodate emerging ontologies and design methodologies.

New structural engineering

As 3D printing enables the fabrication of buildings and organic matter, robotics nears anthropomorphic autonomy, and data is increasingly stored in DNA, architecture adapts to these evolving conditions. Architecture's alignment with quantum cosmology positions it as a vital interface between humanity and its environment. Structural engineering, likewise, must evolve alongside architecture, integrating emerging paradigms and technologies.

Architect Ayssar Arida articulates a set of "attitudes" in quantum architecture that translate into design principles with implications for structural engineering. These attitudes reflect quantum theory's emphasis on interconnectivity, probability, and dynamic systems.

First, architecture serves as a memory archive (Arida, 2011) - relational, transdisciplinary, and reflective of a holistic worldview. In this vision, materiality is secondary to the quality and quantity of relationships between different elements, echoing the quantum principle that particles gain substance only through interaction. Thus, architecture and engineering must shift focus from objects to processes, exemplified by Michael Leyton's Symmetry-Curvature Duality Theorem (Leyton, 2004), which redefines form as an expression of historical memory and changing the focus of design from forms to processes (Leyton, 2006), a qualitative approach to geometry and shapes that focuses on immaterial values.

Thus, we can infer that the first step for further developing the research into structural engineering is to find and develop relations with other sciences or knowledge areas like ecology or biology (biomimicry), according to the principles stated further.

Second, architecture's tangible and intangible aspects merge, necessitating the design of both material structures and experiential interfaces – "Physical is secondary: interface and information architecture can be tangible or intangible or both." (Arida, 2011). Quantum theory's dual nature (Zanjoc, 2004) - wave (qualitative) and particle (quantitative) - requires structural approaches that consider psychological and emotional dimensions. The Eiffel Tower's symbolic longevity exemplifies this, its immaterial resonance into the people's mind outweighing its physical design. To think in quantum terms does not mean to think in virtual or physical terms, but both: interaction between tangible and intangible, between material and immaterial.

As humanity is on its way to become a knowledge-based society, research and creativity, coupled with new value systems will clearly formulate new solutions, less expensive in terms of money and, even more important, resources and negative ecologic consequences.

Third, the relational comes before the formal (Arida, 2011). The contemporary timber structures designs reflect ecological principles and quantum connectivity, offering adaptability, efficiency and sustainability. But also, projects like the Infobox in Vienna and the bone-like "Bonescaper" demonstrate how structural systems can evolve, grow, and interact with their users. Structural engineering must now explore biologically inspired, scalable (fractal) systems suitable for high-density environments.

Fig. 4 Infobox for Vienna

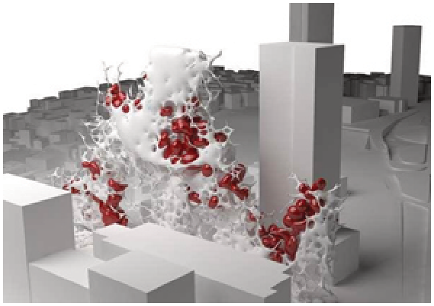


Fig. 5 The Bonescraper

The result: a structure composed of similar elements and a large number of connection points, which pertains to the definition of the quantum world - a universe of entangled, interconnected particles, without a clear form: relational before formal. In recent years architects and structural engineers have created more and more structures of this kind (fig. 4,5) for their obvious and incontestable attributes: the similar small elements and connections are easy to produce and erect, the structures are light, elegant, inexpensive and versatile, easily adaptable and most of the times ecological.

Fourth, architecture must be contextual, open-ended, and responsive to temporal, spatial, and societal conditions (Arida, 2011). As globalized production has alienated architecture from local environments, new paradigms demand structures that adapt, evolve, and integrate diverse inputs. Buildings should internalize the technological and cultural DNA of their era. Emerging technologies such as 3D printing facilitate this, enabling localized, adaptive, multifunctional structures that mirror natural processes (Guallart, 2008).

Fig. 6 Monocoque

Architect Neri Oxman's Monocoque 1 (fig. 6) exemplifies this shift. A 3D-printed composite of structural and permeable materials, it adapts to environmental stimuli, blending form and function in a biologically inspired system. Though experimental, it illustrates architecture's potential, including its structure, to become a self-regulating, integrated component of the ecosystem.

In sum, the quantum paradigm reorients architecture and structural engineering toward relational, adaptive, and ecological models, capable of responding to and co-evolving with the complexities of contemporary life.

Conclusion

In the recent years it is clear that we are living in a society in crisis. But what was thought to be a possible gloomy future, now appears as a transformation period that started with the formulation of a completely new and astonishing scientific quantum cosmology and "affected" the entire human society by the way of radically altering our ontology. Slowly, with great inertia, human society starts to overcome its own mechanistic and materialistic mentalities and, almost forced by contemporary contexts (scientific discoveries, technological advancement, ecologic crisis, lack of resources, etc.), starts to adopt new paradigms and by this, to reposition itself in relation with its existential universe. This process gives rise to new thinking lines, new paradigms, new living patterns and new production and new consumption patterns.

There are four major conceptual clusters defining the current architecture's "crisis" identified by architect Ayssar Arida that gives us the possibility to infer on the future development of the fields of architecture and structural engineering. The first promotes a holistic, ecological approach rooted in transdisciplinarity, creativity, and ethical responsibility, where built structures serve as repositories of knowledge and experience. The second explores duality, addressing both quantitative and qualitative values, and how architectural form emerges from the interplay of material and immaterial forces. The third emphasizes biomimicry, urging architecture to emulate living organisms and ecological systems, viewing buildings as dynamic entities integrated with their environments. The fourth focuses on contextual adaptability—buildings must simultaneously reflect local specificity and universal principles, remaining open-ended and capable of evolving with changes in society, technology, and the environment.

Possibly the largest source of innovation comes from the interconnection with other sciences, for example biomimicry or robotics. In this way structures can obtain complexity and become ecological and integrated to local ecosystems in both their material and immaterial aspects, in both quantitative and qualitative values. Quality is more important than quantity, quality is the reason for quantity, the idea is the reason for form, in the sense that what matters is the holistic approach. A "nature 2.0" approach in which natural and built environment become an integrated ecological entity through establishing sustainable interexchange and interconnections that are global and local at the same time, open-ended and evolutive, multifunctional and polysemantic.

In a time in which computers can generate an immense computing power for the exploration of all possible solutions, the human spirit is left with the task of creatively search for ways to provide architectures and structures with the above-mentioned properties that we now know and understand they should possess.

References

Arida, A. (2011). Urbanism and Architectures of the Quantum Paradigm. in OOSTERHUIS, K. & Feng, H. & Xia, X. (eds) 2011, iA#4. Quantum Architecture : 50-55, Heijningen : Jap Sam Books

Flachbart, G. & Redi, I. Boulevard of Production: a Future Talents Attractor. A Retro-innovation for Graz 8020 & co. in OOSTERHUIS, K. & FENG, H. & XIA, X. (eds), (2011), iA#4. Quantum Architecture : 38. Heijningen : Jap Sam Books

Guallart, V. (2008). Geologics. Geography Information Architecture. : 59. Barcelona/New York : ACTAR

Leyton, M. (2004). Symmetry-curvature duality. https://www.sciencedirect.com/science/article/abs/pii/0734189X87901174

Leyton, M. (2006). Shape as Memory. A Geometric Theory of Architecture. Basel : Birkhauser

Oosterhuis, K. & Feng, H. & Xia, X. (eds), 2011, iA#4. Quantum Architecture : 38. Heijningen : Jap Sam Books

Smythies, J. R. (2003), Space, time, consciousness, article published in Journal of Consciousness Studies, no. 3, page 47-56, introduction.

Zajonc, A. ed (2004). Dalai Lama: The New Physics and Cosmology. : 29. Oxford: Oxford University Press

Lobell, J. (2003). Quantum Theoretical Issues in Architecture: It's A Lot Stranger Than We Think (https://johnlobell.com/quantum-theoretical-issues-in-architecture-its-a-lot-stranger-than-we-think/)

Noi idei arhitecturale necesită noi inginerii structurale

(rezumat)

Societatea umană evoluează prin relații interconectate și este modelată istoric de viziuni cosmologice care au influențat cultura și arhitectura. Cosmologiile religioase au dominat până în secolele XVI-XVII, când Galileo și Descartes au introdus primele paradigme științifice. Fizica newtoniană a definit secolele XVIII-XIX, relativitatea a marcat secolul XX, iar secolul XXI se angajează în perspective cuantice și holistice. Aceste schimbări, alături de transformările tehnologice, sugerează o tranziție către o viziune asupra lumii mai integrată, vizibilă în arhitectură. Arhitectura reflectă cosmologiile predominante: modernismul a

oglindit raționalismul newtonian, postmodernismul a exprimat pluralitatea relativistă, iar cosmologia cuantică – care pune accent pe interconectivitate și emergență – inspiră designul parametric și cuantic. Aceasta afectează estetica, metodele de construcție și relația dintre arhitect și inginer. Astăzi, abordările holistice încurajează colaborarea, aliniindu-se cu o convergență științifică mai amplă. Arhitectul și inginerul împart acum responsabilitatea pentru crearea unei arhitecturi adaptive, ecologice, sistemice, orientate către paradigme biologice emergente, remodelând astfel spațiul, structura, funcția și experiența.