Acceptance speech

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Pablo Jarillo-Herrero, awardee in the Basic Sciences category (18th edition)

It is a great honor to receive the Frontiers of Knowledge Award in Basic Sciences, and even more so to share it with my friend Allan MacDonald. I am deeply grateful to the BBVA Foundation, the committee, and our nominators for making this happen. I take this as recognition of many years of hard work by my wonderful group of students and postdocs at MIT. This prize is as much theirs as mine.

I really like the name of this award, because it contains some of my favorite words, words that capture how I see my life's journey as a scientist. Let me start with "Frontiers." This prize rewards a discovery that was very unlikely to happen. It took an adventurous group of researchers to explore the frontier of what was possible in physics and materials science. This meant taking a substantial risk, motivated mainly by intellectual curiosity. Let me explain. When we think about what determines the properties of materials, we tend to think first about chemical composition: gold is a metal, iron is a magnet, and silicon is a semiconductor. If one digs deeper, one realizes that structure is also crucial: for example, it is what distinguishes diamond, a transparent insulator made entirely of carbon, from graphite, a shiny conductor also made purely of carbon. Usually, however, the laws of nature determine the structure of a material; there is not much we can do about it. At least that was the case until two-dimensional materials appeared. With two-dimensional materials, such as graphene, a single-atom-thick sheet of graphite, we can do something that had been impossible in the history of materials science. We can take one sheet of graphene and place it on top of another graphene sheet with any angle of rotation, or twist angle, that we want.

In other words, we can design and change the geometry of materials, in particular the twist angle between crystalline planes, completely at will. And the amazing thing is that the electronic properties of the twisted structure can change dramatically compared with those of the constituent layers. Graphene, for example, is a metallic conductor, but not a superconductor and definitely

not an insulator. Yet by placing graphene on graphene at an angle of 1.1 degrees, which Allan named the magic angle, we can turn twisted bilayer graphene into a superconductor or an insulator. In fact, we can also make it behave like a magnet, and like many other things. This field, in which we change the properties of materials by playing with geometry or twist angle, is now known as twistronics, short for twist-electronics, and it is one of the fastest-growing fields in physics. This feels a bit like magic, right? In medieval times, alchemists searched for the philosopher's stone that would turn everything it touched into gold. Magic-angle graphene is a little bit like that, except that it is the inverse of a philosopher's stone. With magic-angle graphene, we take a single material and make it behave like many other materials. Because this behavior is deeply quantum mechanical, one can think of magic-angle graphene as a quantum inverse philosopher's stone.

But let me return to the title of the award and the other words that I like: *Knowledge* and *Basic Sciences*. This award recognizes the generation of new knowledge, and especially the importance of basic science research. Basic science rarely has immediate applications, but history shows that the deep knowledge and paradigm shifts it creates often lead to transformative technological revolutions, with important social and economic consequences for humankind. When physicists discovered the laser, no one was thinking that it would become the basis of optical communications or be used to operate on cataracts. When physicists invented the atomic clock, no one imagined that it would be crucial for GPS navigation. Curiosity-driven research pays off in the long run, and we need society, politicians, philanthropists, and the private sector to support it.

On this topic, I want to conclude with a few more words of acknowledgement. I would like to thank the people who have supported our research, including federal funding agencies, private foundations, and companies. For the discoveries recognized by this award, the support of the Gordon and Betty Moore Foundation and the US National Science Foundation were particularly important. It is crucial for the future of humanity that public research agencies and private foundations continue to support basic science, based purely on merit and independent of politics. Finally, I want to thank my family: my parents, who could not go to college themselves but understood the importance of education and sacrificed so their children could have a better future; and my wife Empar and my three kids, Marta, Maria, and David, for their unwavering love and support, and for making me a better person.