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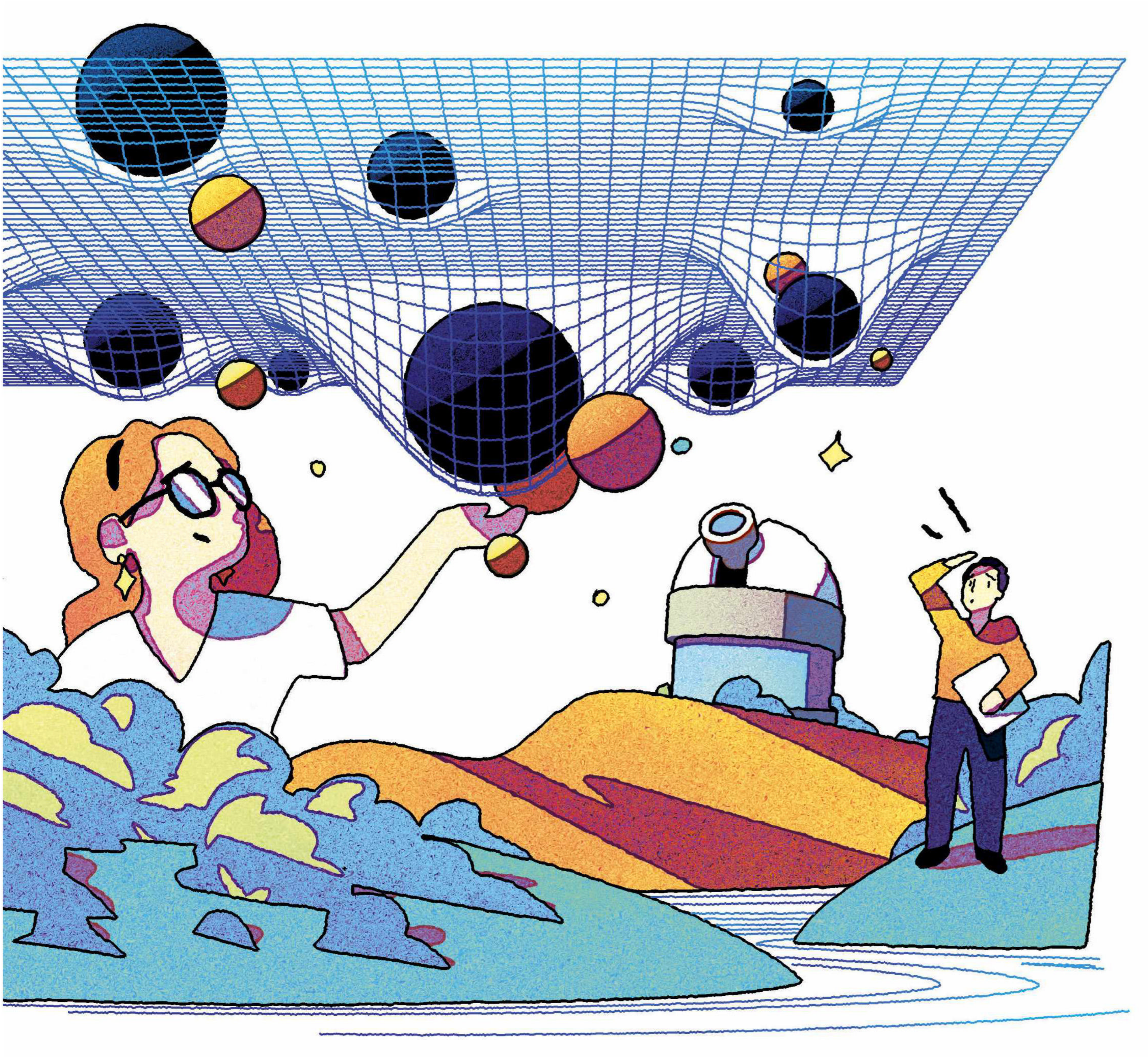

COMMENT

GETTING TO THE HEART OF THE (DARK) MATTER

We've mapped it, but the exact nature of dark matter remains elusive. And for most astronomers that's okay

In early August, astronomers announced that they had created a map of dark matter from the early Universe. Dark matter is the mysterious, invisible stuff that astronomers say underlies all structure in the cosmos.

Articles reporting the achievement described the innovative observational technique of searching for tiny distortions of patterns in the cosmic microwave background radiation, the backlight of the Universe that originates from the Big Bang. These distortions appear because mass bends space, even if that mass belongs to an invisible kind of matter.

Tellingly, these reports did not delve into the mystery of what dark matter is, or question whether it even exists. For most astronomers, most of the time, dark matter's fundamental nature is entirely beside the point. Despite having never directly detected it, scientists have good reason to believe that dark matter is real.

The first story that everyone tells is that galaxies seem to be rotating at impossible speeds. The stars at the outer edges of spiral galaxies are orbiting around the centre so quickly that if something wasn't providing extra gravity to hold them in, they would have already escaped into intergalactic space, like children flung off a merry-go-round that's spinning too fast.

The proposed solution: an invisible, intangible substance – presumably composed of a collection of particles our Earth-based experiments have all missed – surrounds and penetrates the misbehaving galaxy, and its mass provides the extra gravity the observations require.

It's not unreasonable to point to another possibility: maybe we don't need something new to produce more gravity; maybe gravity just acts differently from what we thought. This has been the main approach of dark matter sceptics in astrophysics, and when it comes to galaxy rotation, it seems to be an appealing solution. These modified gravity models work so well to solve the rotation problem that articles regularly appear in papers and magazines proclaiming that dark matter has been disproven by a simple tweak to Newton's (or Einstein's) laws.

But there's a reason why we haven't all thrown out dark matter and embraced the demise of gravity as we know it: the best evidence for dark matter comes from cosmic phenomena occurring on scales much larger than any galaxy, where there are fewer observational complications and where the agreement with theory is incredibly precise.

That preponderance of evidence would be compelling even if we completely ignored galaxy rotation, and there has yet to be a modified gravity theory that can compete with dark matter when it comes to everything else: galaxy shapes, galaxy cluster motions, gravitational lensing, elemental abundances from the early Universe, the distribution of galaxies on the largest scales, and even the patterns in the cosmic microwave background light itself.

Even accepting that the astrophysical evidence is strong, it's understandable to remain uncomfortable with the notion of adding a dark matter particle to the zoo of discovered species without any concrete detection of the particle itself.

Some of the simplest theoretical possibilities for dark matter's particle properties have already been ruled out. But rather than give up entirely, astronomers and physicists are constantly searching for new, creative ideas for what dark matter might be and why it hasn't shown up yet. In spite of the experimental no-shows, when all the evidence is taken into account, the idea that the Universe is overrun by invisible particles just fits the data best.

In cosmology, we sometimes loftily describe our mission as "solving the mysteries of the Universe", but in a day-to-day sense, our job is to build and test mathematical models to describe the data we collect. Not detecting a particle in a detector might make us uncomfortable, but it doesn't cancel out any of the ways in which we see dark matter's influence in the cosmos. And there's no indication that dark matter ought to be something that interacts with detectors at all.

It's still possible some other solution will be found. But whatever it is, it will have to look, observationally, exactly like a collection of invisible, untouchable particles making up most of the matter in the Universe.

Whatever dark matter is, we can be grateful for its role in bringing all that ordinary matter together, and rest assured that it's likely to continue doing a great job of keeping our Sun from flinging itself off into the void.

"It's understandable to remain uncomfortable with the notion of adding a dark matter particle to the zoo of discovered species without any concrete detection of the particle itself"

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