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Music

Phantom notes played by violins turn out to be real

Karmela Padavic-Callaghan

A MUSICAL sound once thought to be heard only in our heads as a quirk of the ear canal is actually real. Violins can produce these unusual tones – and higher quality instruments can produce them more strongly.

In 1714, Italian violinist Giuseppe Tartini discovered that, when playing two notes simultaneously, he unexpectedly heard a third sound. This third note was later named a combination tone because it is a blend of the frequencies of the two original tones. It was thought that these tones arose entirely in our ears, due to the way sound is amplified by the cochlea, rather than actually emanating from an instrument.

Giovanni Cecchi at the University of Florence in Italy and his colleagues decided to investigate how different violins produce combination tones. They recorded a professional violinist playing selected pairs of notes on five violins and used a computer to decompose the sound waves.

PEH ALEXANDRE/EYEEM/ALAMY

Violins can produce seemingly 'phantom' notes

They found that all the violins produced combination tones, but the ones produced by a vintage, high-quality violin were about 75 per cent louder than those from a modern, mass-produced instrument (*The Journal of the Acoustical Society of America*, doi.org/gq53b8).

The researchers now want to study more violins to pinpoint exactly which part of the instrument is responsible for the combination tones, says Cecchi.

Astronomy

Crooked star clusters may signal Einstein was wrong

Leah Crane

NASA, ESA, AND STSCI.

The distribution of stars in the Hyades cluster is lopsided

A STRANGE effect in clusters of stars is bringing our ideas of how gravity works into question. These star clusters seem to have an unexpected asymmetry, which fits better under an alternative theory of gravity called modified Newtonian dynamics (MOND) than under Albert Einstein's widely accepted theories.

Clusters of stars, which orbit the centre of their galaxy, typically look a bit like a two-armed pinwheel with opposing tails – though they don't spin. The tails are formed when stars bouncing around in the cluster begin to travel either slightly faster or slower than the cluster as a whole. The leading tail is made up of stars that are slightly closer to the galaxy's centre and the trailing one is made of stars that are slightly further from the galactic centre and that fall behind.

In standard, or Newtonian, gravity, we would expect the two tails to be roughly equal: as stars bounce around within the cluster, they should be equally likely to end up in either tail. But when Pavel Kroupa at the University of Bonn in Germany and his colleagues examined three stellar clusters, they found that wasn't true. The leading tails all had more stars than the trailing ones. Simulations showed that this asymmetry was a better match to the predictions of MOND than those of Einstein's general relativity (*Monthly Notices of the Royal Astronomical Society*, doi.org/gq4trz).

"It's like there are two doors to escape the cluster, and the stars can only pass through the doors if they have the right direction and the right energy – otherwise they will just bounce around within the cluster," says Kroupa. "In MOND, the front door is simply bigger."

50%

Decrease in the lifetime of a star cluster under modified gravity

Because of the way that gravitational effects compound with one another in MOND, the forces pulling stars towards the centre of the galaxy, and therefore towards the leading tail, are stronger than in Newtonian gravity.

In the simulations, this had broader effects for entire clusters. More stars bouncing to the leading tail made the cluster spin and slow down. Eventually, the clusters fell apart. Under MOND, the clusters had lifetimes between 20 and 50 per cent of those experiencing Newtonian gravity. This would roughly match what astronomers have observed, says Kroupa.

But with only a few clusters tested for this effect, it isn't yet time to bin Newtonian gravity. "It's somewhat promising, but it does not provide completely definitive evidence for MOND," says Indranil Banik at the University of St Andrews, UK. "This asymmetry does make more sense in MOND, but in any individual cluster there could be other effects that are causing it – it's a bit unlikely that would happen in all of them, though."

To show that this asymmetry is caused by MOND, we will have to observe many more star clusters in detail, and it will have to pass other cosmic tests as well. Many cosmologists are sceptical of MOND, partly because it doesn't seem to fit with observations of the universe on the largest scales and partly because of the huge consequences if it is real.

"If MOND is correct, then all calculations regarding galaxies, galaxy formation, galaxy interaction and much of the whole universe are completely wrong," says Kroupa. "We would have to reset – reinvent cosmology, basically." The evidence required to do that would be more than a few crooked clusters.