# Are molecules right-handed or left-handed? Properties of chiral molecules at the attosecond level

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You can get a good idea of chirality by putting a right-handed glove on your left hand—two identical shapes that cannot be superimposed because they are mirror images of each other. This property is common in our universe, from the smallest particles to huge galaxies.

Although the physical characteristics of chiral molecules are the same, only one of the forms is generally used by living organisms, for example in DNA or amino acids. There are many possible reasons why this "homochirality of life" exists, but no consensus on the definitive explanation. Yet the consequences of this phenomenon are immense, for example in pharmacology, where the two mirror images of a chiral molecule can have very different therapeutic effects.

To reveal the subtle properties of mirror molecules in a new study, an international research team examined their photoionization, namely the way they emit electrons when hit by light. Light produced by an ultrafast laser at Centre lasers intenses et applications (CELIA, CNRS/University of Bordeaux/CEA) in Bordeaux was circularly polarized and then directed at camphor molecules. This made the electromagnetic field take on a regular spiral shape whose direction could be changed. When struck by this spiral-shaped light,a chiral molecule emitted an electron, which also followed a spiral path.

Gaseous camphor molecules are oriented in a random fashion, so the laser beam doesn't always hit the chiral molecule on the same side, and electrons are emitted in different directions. Yet for a given mirror image, more electrons are emitted either in the same or opposite direction as the light, depending on the direction of the polarization, just like a nut turns one way or another depending on which direction the wrench is turned.

Samuel Beaulieu, a Ph.D. student in energy and materials co-supervised at lNRS and the University of Bordeaux, investigated the source of this phenomenon with his colleagues by measuring very precisely how the electrons are emitted. This not only enabled him to confirm that more electrons are emitted in one direction, but also led him to discover that they were emitted seven attoseconds earlier than in the opposite. So the reaction of a camphor molecule ionized by circularly polarized light is asymmetric.

The asymmetric ionization of chiral molecules is one possible explanation of the homochiral nature of living organisms. Samuel Beaulieu's experiment captured the first few attoseconds of a process that over billions of year of evolution could have led to a preference for certain left-handed or right-handed molecules in the chemistry of life. It will take other fundamental discoveries like this one before we understand all the steps in this story, which take place in attoseconds.

**More information:** "Attosecond-resolved photoionization of chiral molecules," *Science*, December 7, 2017. science.sciencemag.org/cgi/doi … 1126/science.aao5624

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