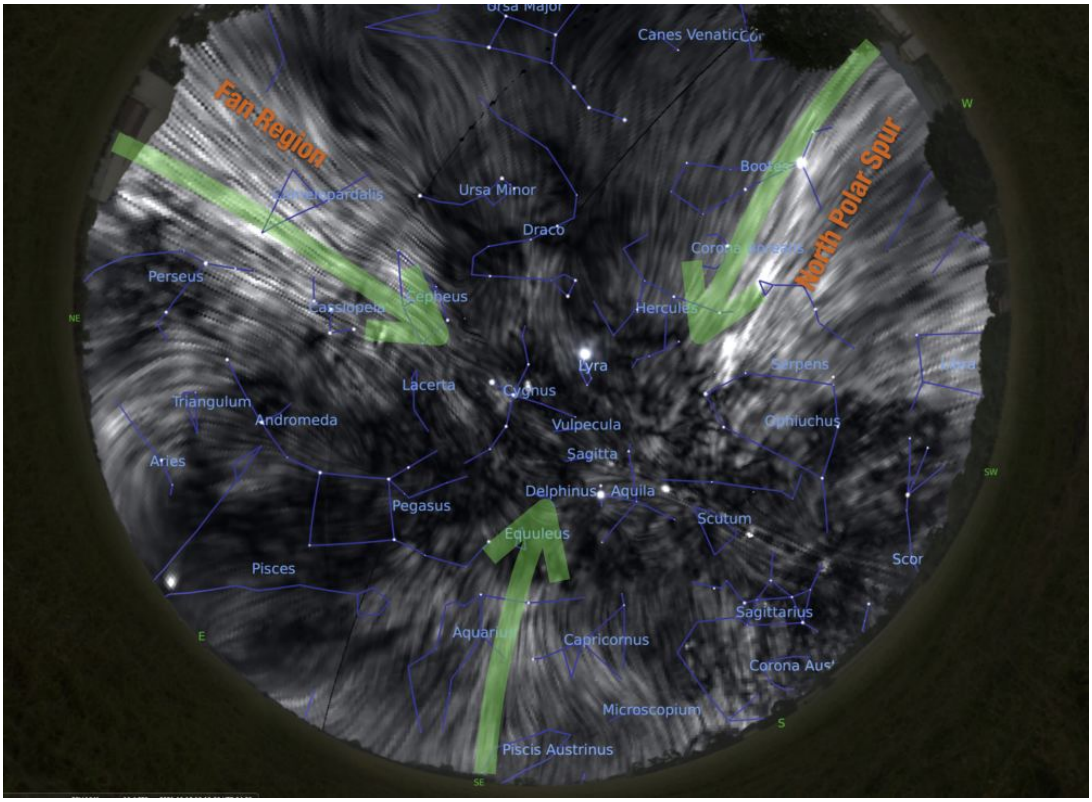
A magnetic tunnel of rope-like filaments made of radio waves surrounds the Earth

Oct 27, 2021



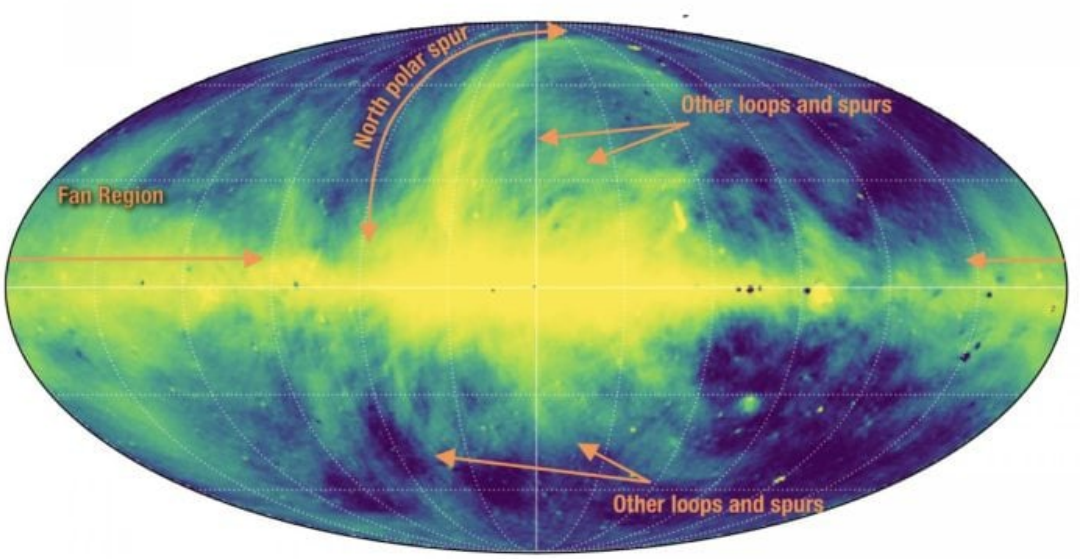
A magnetic tunnel surrounds Earth

What if our eyes could see radio waves? If we could, we might be able to look up into the sky and see a tunnel of rope-like filaments made of radio waves. The structure would be about 1,000 light-years long and would be about 350 light-years away. This tunnel explains two of the brightest radio features in the sky.

Astronomers discovered the North Polar Spur and the Fan Region in the 1960s when radio astronomy was getting going. The North Polar Spur is a massive ridge of hot gas that rises above the plane of the Milky Way. It emits x-rays and radio waves.

Over the decades since its discovery, there's been an ongoing discussion about what it actually is and how far away it is. Astronomers thought it could be related to the Fermi Bubbles or a feature carved out by ancient supernovae explosions.

The Fan Region is one of the most dominant polarized radio features in the sky. There's debate about the nature of the Fan Region, too, with some saying it's a local feature and some arguing that it's on a galactic scale.

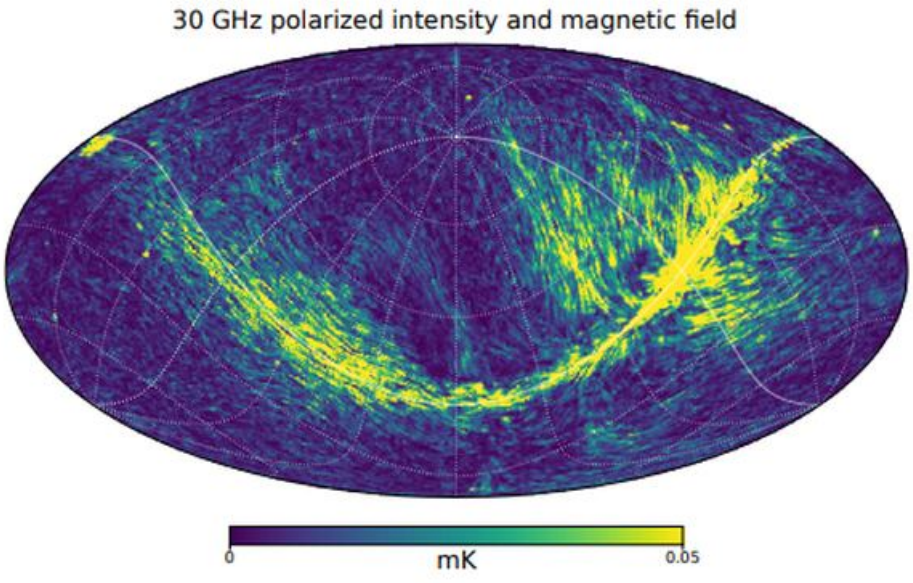


Our Galaxy seen in radio waves in the conventional view with the Galactic centre in the middle of the image. Credit: Haslam et al. (1982) with annotations by J. West.

A team of researchers from Canada and the US presents evidence in a new paper showing that the pair of features are connected.

The authors say that both the NPS and the Fan Region are parts of the same feature. **The feature is made up of 1,000 light-years long "ropes," which themselves are made up of charged particles and a magnetic field. They're right in front of our eyes, but we can't see them.**

"*If we were to look up in the sky,*" explains West, "*we would see this tunnel-like structure in just about every direction we looked – that is, if we had eyes that could see radio light.*"



This image from the new study shows the magnetic tunnel at 30 GHz. The North Polar Spur sweeps up and to the right, while the Fan Region is on the left. Image Credit: West et al., 2021.

"***Magnetic fields don't exist in isolation,***" West explains in a press release. The trick was to figure out how these two were connected. **West thinks that her team is the first group of astronomers to join the pair of features.**

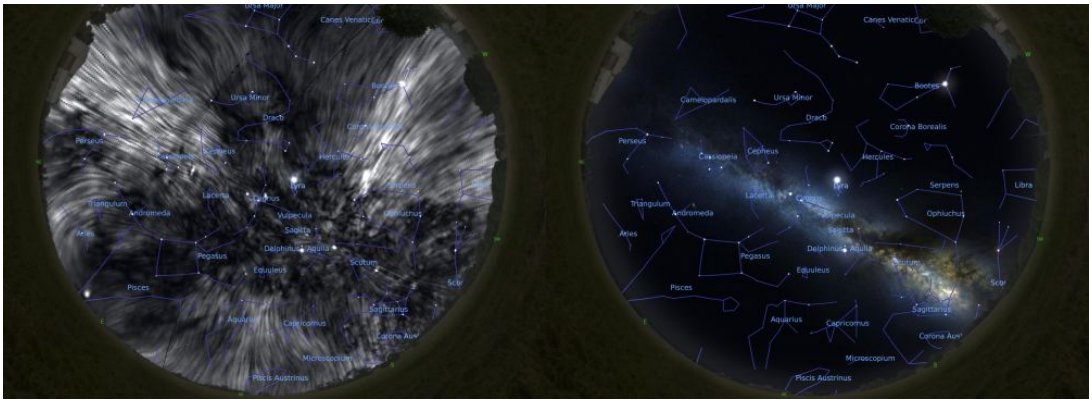
West says she's been thinking about the pair of features for 15 years since she first saw a radio map of the sky. In recent years she's built a computer model that shows what the radio sky would look like from Earth as she changed the shape and location of the long radio ropes.

The model made it possible to "build" the radio structure around us. It showed her what the sky would look like through radio telescopes. The model gave her a new perspective that helped her match the data to the observed data.

"*A few years ago, one of our co-authors, Tom Landecker, told me about a paper from 1965, from the early days of radio astronomy,*" West said. "*Based on the crude data available at this time, the authors (Mathewson & Milne), speculated that these polarized radio signals could arise from our view of the Local Arm of the Galaxy, from inside it. That paper inspired me to develop this idea and tie my model to the vastly better data that our telescopes give us today.*"

West compares their work with a map of the Earth. The North Pole is on top, of course, and the equator is in the middle. But it can be drawn from a different perspective, which is what West's computer model allowed her to do.

"*Most astronomers look at a map with the North pole of the Galaxy up and the Galactic centre in the middle,*" she explains. "***An important part that inspired this idea was to remake that map with a different point in the middle.***"

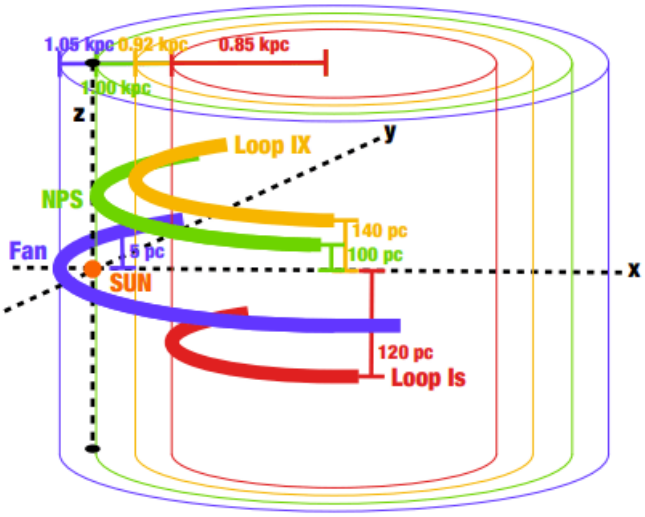


Left: The sky as it would appear in radio polarized waves. The Van-Gogh-like lines show the orientation of the magnetic field. These radio data are shown projected as they would be seen in the sky together with the brightest stars and constellations outlines and constellation names overlaid. Credit: Dominion Radio Astrophysical Observatory/Villa Elisa telescope/ESA/Planck Collaboration/Stellarium/J. West. Right: the sky in the same orientation and projection, as it can be seen with our eyes. The same brightest stars and constellations as in the previous image are shown. Credit: Stellarium/J. West.

"This is extremely clever work," says Dr. Bryan Gaensler, a professor at the Dunlap Institute and an author on the publication. "*When Jennifer first pitched this to me, I thought it was too 'out-there' to be a possible explanation. But she was ultimately able to convince me! Now I'm excited to see how the rest of the astronomy community reacts.*"

West is an expert in galaxies and the ISM. She's looking forward to more research that can hopefully discover how the various magnetic structures in the sky are connected.

"***Magnetic fields don't exist in isolation,***" she explains. "***They all must connect to each other. So a next step is to better understand how this local magnetic field connects both to the larger-scale Galactic magnetic field and also to the smaller scale magnetic fields of our Sun and Earth.***"



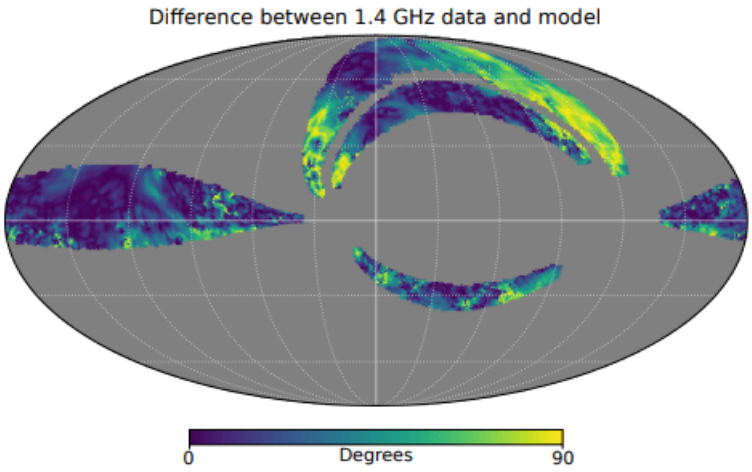
This figure from the study shows the arrangement of some of the loops constructed on nested cylinders. The diagram is not to scale, but the placement of the filaments is correct with respect to the Sun's position and relative to each other. Image Credit: West et al. 2021.

We can't see these structures with our eyes. But knowing they're out there is thought-expanding.

"***I think it's just awesome to imagine that these structures are everywhere whenever we look up into the night sky,***" said West.

For years, astronomers have argued over the nature of the North Polar Spur. Different research has produced contradictions. Some studies show it's a distant feature, while others show it's more local. West and her co-authors say their paper has resolved these contradictions. "***We show this model is consistent with the large number of observational studies on these regions and is able to resolve an apparent contradiction in the literature that suggests the high latitude portion of the NPS is nearby, while lower latitude portions are more distant.***"

"***This model has implications for developing a holistic model of magnetic fields in galaxies,***" the authors write. "***We still do not fully understand the origin and evolution of regular magnetic fields in galaxies and how this field is maintained.***"



The model isn't a perfect match with observations. The yellow regions show polarization disagreement between the model and the data in this image from the study. But the areas of disagreement are primarily on the ends of the NPS. The team thinks that some foreground structure is causing some depolarization and say that the model still broadly agrees with the data. Image Credit: West et al. 2021.

The team hopes a better understanding of features like the tunnel will lead to a better understanding of more distant magnetic features. **Filaments much more extensive than these exist, and so do bubbles and super-bubbles. Astronomers have observed them in more distant regions of the Milky Way.**

But studying these more distant features is difficult. "*Thus, it is likely that we do not currently have the resolution and sensitivity to see this level of structure in many locations except the local environment and possibly in the Perseus arm,*" the team concludes. [Arxiv, PDF, Dunlap, Universe Today]

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