FeedHorn vs. Helix Feed

(In the area of RFI and Side RFI*)*

by

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As a general rule, a feedhorn, when it's important that the sidelobe response and susceptibility to RFI be as small as possible. A helix has a notoriously poor sidelobe and susceptibility to RFI response.

Why is this? I can't remember seeing a published discussion of exactly this point, but I'll make up some possible explanations! With a feedhorn, the field distribution (both E and H) across the aperture is very well defined, and also naturally tapers towards the edge of the aperture - for example, the E field has to become zero at the point where it's tangential to the metal surface. As you know, a nicely tapered aperture illumination distribution is just what you want to minimize sidelobes. It's no accident that a feedhorn is often used as a standard gain antenna on antenna test ranges.

The axial-mode helix is a traveling wave antenna, but has (as you can derive yourself or as the text books say) 3 regions of current: (1) the traveling wave going down the length of the helix, which is responsible for the gain and directivity, (2) a reflected wave from the far end of the helix, traveling back towards the feed, which may be responsible for a strong back-of-the beam response, and (3) a much higher current region, over the first turn or 2 of the helix from the feed point, which is (as one text I have puts it) responsible for launching the wanted traveling wave along the helix. This current rapidly decreases from the feedpoint to the "normal" traveling wave region of the helix, within the first couple of turns or so. I'm guessing that most of the sideways radiation comes from this "wave launching" current. That's also one reason that the main-beam pattern of a small helix, with only a few turns, is almost always decidedly skewed. It's not until you have enough gain to swamp the effect of radiation from the first couple of turns that the main beam start looking reasonable.

There's one more effect I can think of. With a plane aperture across a feedhorn, there's a natural cosine (theta) effect in the feed pattern, that multiplies the directive pattern you get anyway from the broadside radiation from the aperture. That will tend to reduce further the sideways radiation from a horn.
With a helix, even from the traveling wave part that's responsible from the gain and directivity, there's no such cosine (theta) effect. You only get diminished sideways radiation because adjacent segments of field along the length of the helix, every half-wave, cancel each other out. The degree of cancellation broadside to the helix will be poor for an odd number of half-waves in antenna length (but you have to take into account the phase velocity down the helix, which isn't the same as free space). This statement is modified because the current in the traveling wave diminishes as you move down the helix, because energy is lost to radiation, but the principle is the same.

One more thing about the axial-mode helix: the gain claimed by Kraus, who invented the helix, is a few dB optimistic compared either to experimental measurements or to numerical modeling of the helix antenna. If you look at Kraus' original papers, he derived an antenna gain from the directivity of the antenna - roughly, dividing the beamwidth into 4.pi steradians gives you the antenna gain. That would be true if there were no power in the sidelobes. However, if you start integrating the power going into the sidelobes of a helix antenna, you find that very often more than half the power is in the sidelobes - the fact that sidelobes might be 20 dB down (they're not) doesn't matter, because the total solid angle covered by all the sidelobes is so much bigger than the solid angle of the beam beam. For example, if you had an antenna with a 10-degree beam, that's about one four-hundredth of the entire sphere. [Roughly 100 square degrees in the main beam compared to ~40,000 square degrees in a sphere – ignoring factors or order pi/2.] So, if you had uniform sidelobes that were some 26 dB down on the main beam, roughly half of the energy would still be going into the sidelobes rather than into the main beam. So (in my opinion) Kraus overestimated the gain of the helical antenna because he derived his gain from the beamwidths, rather than a true gain measurement, and he didn't take account of so much of the power (typically more than half) being lost in far-out sidelobes.