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The Importance of Electromagnetic Shielding in the SOFIA Telescope

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The NASA Stratospheric Observatory for Infrared Astronomy (SOFIA) airborne telescope will be used for noise-limited measurements made with sensitive electronic detectors. These detectors are usually sensitive to spurious electromagnetic radiation and field fluctuations at radio frequencies and at low frequencies near 20 Hz. The instrument builder must make sure that the detector is shielded from the electronically and electromagnetically noisy environment of the airplane. This cannot be done perfectly, however, because the shielding around the detector must have an opening to admit the signal from the telescope. The purpose of this note is to point out that a few kilograms of inexpensive electromagnetic shielding material built into the telescope at the time of its construction would provide a large improvement in shielding that may mean the difference between success and failure to some instrument systems.

The unwanted electromagnetic fields in SOFIA arise in onboard electronic equipment, the airplane's radio transmitters, and stray magnetic fields from the telescope drive motors. The field strengths and power levels are not large. If we wish to shield a volume against these fields and could do it with a seamless shield completely surrounding the surface of the volume with no openings, then two layers of sheet metal would suffice: an outer layer of high-conductivity low-saturation material (copper or aluminum) and an inner layer of high-permeability ferromagnetic material (nickel steel). Naturally thicker sheet metal provides better shielding, but if both layers were 2 mm thick, this would provide essentially perfect RF shielding and about 30 dB of magnetostatic shielding (Ott, 1988). The instrument builder could construct such a shield around the detector, but would find that the field strengths inside the box would be dominated by stray fields leaking in the optical window.

One solution to this problem is to place a grid of (possibly superconducting) wires in the window, but this will attenuate the signal and add noise, and is not a really effective shield. Another solution is to extend the shielding out along the optical beam path, so that the shielded volume takes the form of a long, thin cylinder. If the cylinder is ten times longer than it is wide, this shields magnetostatic fields and electromagnetic wavelengths shorter than the tube diameter nearly as well as

the completely enclosed volume (Rikitake, 1987). This geometry can be applied to SOFIA in a natural way by lining the optical beam tube through the air bearing with shielding. These layers of sheet metal are easy and inexpensive to add to the telescope in the design stage, and may be difficult to add later.

Care must be taken in the joints between parts of this shielding; in particular, it is important that the instrument end of the shield be accessible to the experimenter so that it can be clamped to the (incomplete) shield surrounding the instrument. Thin slots and seams in the shield significantly reduce its effectiveness. A number of commercial vendors specialize in the fabrication of seamless electromagnetic shields.

Care must also be taken in selecting the high-permeability magnetoferric material, because the materials with the highest permeabilities (like mu metal) are tricky to use: they must be annealed after fabrication, and may change their magnetic properties with time and mechanical shock. In this application a ferromagnetic steel (silicon steel) may be a better long-term choice.

Electromagnetic shielding for SOFIA instruments is difficult because the instrument window cannot be completely enclosed; the leakages that would otherwise occur can be prevented by extending the shielding into the telescope itself, a modification best considered at the design stage.

References

Rikitake, T. 1987, *Magnetic and Electromagnetic Shielding*, (Reidel: Dordrecht) p.p. 3-106.

Ott, Henry W. 1988, *Noise Reduction Techniques in Electronic Systems*, (Wiley Interscience: New York) p.p. 180-185.