Suitability of On Axis Reflector Designs for Space

Clem Pryke

CMBpol Technology Workshop

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Disadvantages

- Blockage of primary aperture by secondary
  - Produces near sidelobes and loss of efficiency
  - Large field of view requires large secondary making efficiency loss worse

- Secondary support structure scatters light
  - Far sidelobes
  - Further loss of efficiency

- Secondary illuminates annulus between receiver entrance aperture and edge of primary hole
  - More far sidelobes (although can baffle)

- Diffraction from edge of secondary
  - More far sidelobes
Advantages

- None(?)
  - Well actually can have low (zero) instrumental cross polarization
    - But IP is degenerate with rel gain for pair difference systems...
  - And for terrestrial applications cheaper, and easier to rotate around line-of-sight

- Community consensus is that off axis is better:
  - EBEX, CLOVER, POLARBEAR, QUIET, ABS, SPTpol
QUaD Secondary Support Foam Cone

- For on axis polarimeter conventional feedlegs cause problems
- In addition wish to keep mirrors warm to prevent snow accumulation

- Material Zotefoam PPA30 is legendary in the field for its transparency at these wavelengths
  - Polypropylene copolymer expanded using dry nitrogen
  - Used for cryostat windows...

- But manufactured only in 6x3' flat sheets
  - How to make a 9' base diameter cone?
Foam Cone II

- Material can be thermoformed
  - Force into desired shape, heat to 150C, cool, holds shape

- Make 40deg sections of conical surface and trim to fit together

- Glue 2 layers of 9 sections each with joints offset by half a section
  - Make a 1 piece continuous cone

- Need an RF transparent adhesive...
  - Used a 2mil acrylic transfer tape product from 3M
Foam Cone Concept
Thermoforming Oven
Per Section Oven Form
Ahh - The Smell of Fresh Cooked Foam!
Full Size Form and Vacuum Bagging
QUaD at South Pole Feb 2005
Far Sidelobes

- Inner Circular Sidelobe (from reflecting collar) ±7 to 12 degrees
- Radial Sidelobe (from diffracting edge) edge pixel only -15 to -55 deg.
- Diffuse Sidelobe (from cone + primary) center and edge pixels
- Outer Circular Sidelobe (reflection from cone) center pixel: +100 deg., edge pixel: +101 deg.
- Outer Circular Sidelobe (reflection from cone) center pixel: -100 deg., edge pixel: -99 deg.
Caused by reflection from adhesive in cone

- Probed in detail using Sun as source
- Detailed model reproduces contamination in CMB data

Modelling by Tom Vullierens
Conclusions

- QUADE has made the deepest observations of CMB polarization to date
  - But it did this in spite of, rather than because of, its on-axis design

- Likely NASA could make a secondary support structure with far better performance than the one used for QUADE...
  - But there is no reason to do so

- It is recommended that on-axis reflector designs not be considered any further for CMBpol