**A Prototype Luneburg Lens Antenna**

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**Konkur Lenses under construction**

Luneburg Lens Antenna

A Prototype


**REFERENCES**

The Multisat lens has just been delivered to CSIRO, and will be subjected to a range of near and far-field tests; the results will be reported via the Web and at forthcoming SKA gatherings.

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**Enter Konkur**

Konkur Ltd is a Moscow-based company producing, among other products, a line of Luneburg Lenses suitable for satellite TV and other communications applications. Hemispherical lenses up to 8 m in diameter have been made, with the commercial product line extending to spherical 4 m satellite up-link antennas. Working with Konkur, we specified and obtained one of the company’s larger lenses aimed at the European satellite receiving market. This Multisat 1M lens is shown in Figure 3 and has the specifications listed in Table 1. Even though the Konkur lens uses natural dielectric material and is a factor of 10 heavier than an equivalent AD lens, it will be invaluable in testing CSIRO design and analysis software. In a new mount, and equipped with a number of movable feeds, it will also be used as an interference mitigation reference antenna.

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**Table 1. Multisat 1M parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
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<tbody>
<tr>
<td>Diameter</td>
<td>2r = 0.9m</td>
</tr>
<tr>
<td>Operating frequency range</td>
<td>1 to 12 GHz</td>
</tr>
<tr>
<td>Gain (12 GHz)</td>
<td>39 ± 0.5 dB</td>
</tr>
<tr>
<td>Aperture efficiency</td>
<td>&gt;50%</td>
</tr>
<tr>
<td>Side-lobe level (TV horn feed)</td>
<td>&lt;17 dB</td>
</tr>
<tr>
<td>Focal distance</td>
<td>1.5 y</td>
</tr>
<tr>
<td>Mass</td>
<td>90 kg</td>
</tr>
<tr>
<td>Operating temperature range</td>
<td>-50 to +50°C</td>
</tr>
</tbody>
</table>

One interesting aspect of the Multisat lens is the patented construction method. Using dielectric blocks having tongue and groove surfaces, the lens is assembled with no lossy glue. This is depicted in Figure 4; a smoothed lens, prior to encapsulation, is also shown.

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**Summary**

Luneburg Lens antennas have had some use in military and commercial fields but, until now, no application in radio astronomy. With the growing interest in Luneburgs as an SKA application concept, we have worked with a Russian manufacturer to obtain a 0.9 m diameter prototype lens. This lens will be invaluable in verifying the performance of CSIRO electromagnetic design and analysis software, and will later find application as an interference mitigation reference antenna, either at the AT Compact Array or the 64 m Parkes radio telescope.

**How it Works**

R. K. Luneburg described a spherical lens antenna in 1944 [1]. The lens, shown in cross-section in Figure 1, has a radially-graded refractive index with a maximum value at the centre and a value of unity at the surface. In the case described by Luneburg, the focus is at the surface and the refractive index at the centre is \( n_2 \). Later analyses (e.g. [2]) generalize the lens design to place the focus at arbitrary distances outside (or indeed inside) the sphere. As the focus moves away from the outside surface, the required value of central refractive index drops; for a focus at \( r = 1.5 \), the maximum surface, the required value of central refractive index falls to 1.24. Because of the spherical symmetry, the lens antenna is an “all sky” type – beams are formed optically and, by placing feeds appropriately, one can view many parts of the sky simultaneously.

**Luneburg Lenses – background**

Luneburg Lenses have been used in military and commercial applications, most often in passive radar reflector roles in which part of the surface is coated with metal, causing incident rays from a wide acceptance angle to be reflected back along the same radio path. Perhaps the most ambitious application of the Luneburg concept is shown in Figure 2; this 85-foot hemisphere (with a groundplane to form the image of the missing half of the sphere) was used by the US military in the 1960s as a tracking radar antenna.

The advantages of Luneburg Lenses for the SKA have been summarized in [5]. In essence, the lens allows the formation of high-efficiency beams in many simultaneous directions. Feed types (e.g. single horns, printed focal surface arrays, or wideband log-periodic structures) can be mixed, and the array can be upgraded in beam numbers as funding allows.

**Why haven’t Luneburgs been used more?**

Probably because the push for simultaneous multi-beaming has not been strong. Also, the solid nature of the lens raises challenges in minimizing dielectric material cost, weight and RF loss. Furthermore, one needs to find a way of easily and cheaply mass producing the graded-dielectric lens. CSIRO is now working on these issues, particularly by investigating new artificial dielectric (AD) materials which are much lower in cost and weight than natural equivalents. CSIRO is also developing new electromagnetic design and analysis software, incorporating techniques such as genetic algorithms for optimizing the lens and feed as a single system.

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**REFERENCES**


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**Figure 1.** Luneburg Lens beam forming.

(a) Focussing action of a 1 m lens on 600 ps gaussian pulse (1/7 - 1.7 GHz) incident from the left. Note the broadening of the diffused in the region of highest refractive index.

(b) FTDI electric field image courtesy A. Parfitt, CSIRO.

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**Figure 2.** Enlargement of an amateur picture showing the 85 ft diameter hemispherical lens antenna on Kwajalein island in the 1960s. The antenna was the receive element of the Nike Zeus acquisition radar; a section of the transmit antenna is in the background and the power plant is visible between the antennas.

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**Figure 3.** Konkur Multisat lens antenna being positioned for testing in the CSIRO near-field chamber in Sydney. A 12 GHz horn feed and satellite TV down-converter is visible on the feed arm in the rear.

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**Figure 4.** Konkur lens under construction and prior to encapsulation.