

Postprint of Electromagnetic Interference Analysis of Visitor Electronic Devices at FAST

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Abstract

The 500-meter aperture spherical radio telescope exhibits very high sensitivity, rendering it susceptible to electromagnetic interference from nearby electronic devices. Should such interference exceed the telescope's interference protection threshold, degradation of observational performance will ensue. Through measurements of electromagnetic radiation intensity from tablet computers, digital cameras, and mobile phones conducted in an anechoic chamber, coupled with on-site testing of propagation loss between the telescope and locations including the comprehensive building, electronics laboratory, and observation platform, the interference impact from visitor-carried electronic devices such as tablet computers was assessed. Analysis results demonstrate that the selected sample devices generate interference at varying levels to the telescope. These findings provide a crucial foundation for electromagnetic interference management at the telescope site during its operational phase.

Full Text

Analysis of Electromagnetic Interference from Visitor Electronic Devices at FAST

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Abstract: The Five-hundred-meter Aperture Spherical radio Telescope (FAST) possesses extremely high sensitivity, making it vulnerable to electromagnetic in-

interference from nearby electronic devices. If interference exceeds the telescope's protection threshold, observational performance will degrade. This study evaluates the potential interference to FAST from portable electronic devices carried by visitors, including tablets, digital cameras, and mobile phones. Electromagnetic radiation measurements were conducted in a microwave chamber, and propagation losses between the telescope and key visitor areas—the main building, electronic laboratory, and viewing platform—were measured on-site. The results demonstrate that the tested devices produce varying degrees of interference to FAST, providing a critical reference for electromagnetic interference management at the observatory site.

Keywords: FAST; propagation loss; electronic devices; electromagnetic interference

1. Telescope Interference Protection Threshold

Electromagnetic disturbance that causes system performance degradation is defined as electromagnetic interference (EMI). For radio telescopes, EMI contaminates observational data, increasing the difficulty of subsequent processing. Strong interference signals can even overwhelm the observation data, while unknown periodic interference may mislead researchers and remain undetected. The interference protection threshold serves as the theoretical basis for determining the telescope's susceptibility level, ensuring that any electromagnetic disturbance received by the telescope remains below this threshold to prevent impact on observations.

Using the estimation method specified in ITU-R Recommendation RA.769 and considering FAST's technical characteristics, the interference protection threshold is derived as shown in Table 1.

2. Electronic Device Radiation Testing

2.1 Microwave Chamber Testing

To characterize the electromagnetic radiation from visitors' primary electronic devices, we selected three common portable electronics as test samples: an iPad Air, a mobile phone, and a Nikon D7000 digital camera. Testing was performed in a microwave chamber following the Chinese National Military Standard "Measurement of Electromagnetic Emission and Susceptibility for Military Equipment and Subsystems" (GJB152A), with requirements based on the corresponding standard "Electromagnetic Emission and Susceptibility Requirements for Military Equipment and Subsystems" (GJB151A).

[Figure 1: see original paper]

2.2 Test Results

The test results are presented in Figure 2. Among the device samples, the digital camera in shooting mode exhibited radiation intensity exceeding the military limit RE102 by approximately 10 dB in the 400 MHz-2,000 MHz frequency range, with values at other frequencies approaching the limit closely. In standby mode, the digital camera's electromagnetic emissions remained below the military standard below 400 MHz but exceeded it above this frequency. During mobile phone dialing, since the phone could not communicate with base stations inside the shielded chamber, the dialing process mimicked the future field condition after base station removal. The phone's photography function produced interference exceeding the limit by more than 10 dB in the 1,000 MHz range, while its dialing function exceeded the limit by over 20 dB. The iPad generated relatively minor interference, remaining below the limit requirement at 300 MHz.

[Figure 2: see original paper]

3. Telescope Site Propagation Loss Testing

In addition to the viewing platform, visitor activity areas such as the electronic laboratory and main building are situated on mountainous terrain. Natural barriers including mountains and vegetation increase attenuation during radio wave propagation. To understand the propagation loss from these key visitor areas to the telescope, we conducted both theoretical analysis using the free-space propagation model and on-site measurements.

3.1 Theoretical Analysis

The propagation loss is calculated using:

$$L = P_t + G_a + G_t - P_r - G_r$$

where P_t is the transmitted power, G_a is the amplifier gain, G_t is the transmitting antenna gain, P_r is the received power, and G_r is the receiving antenna gain. The free-space propagation model follows ITU-R P.525-2:

$$L_{fs} = 32.45 + 20 \log(f) + 20 \log(d)$$

where f is frequency in MHz and d is propagation distance in km.

3.2 On-Site Testing

Field measurements were conducted in March 2016 when the reflector panel installation reached 50%-55% completion. The test system consisted of a signal source (Agilent 5181A), pre-amplifiers (ZKL-2+, ZX60-3018G-S+), and a spectrum analyzer (N9020A). Transmitting antennas were deployed at the electronic

laboratory, main building, and viewing platform, while the receiving antenna was positioned 145 m above the FAST reflector center. The measurement layout is shown in Figure 3.

[Figure 3: see original paper]

3.3 Test Results

The measurement results are presented in Figure 4. Within the observation frequency band, the measured propagation loss from the electronic laboratory ranged from 70 dB to 140 dB, exceeding free-space model predictions by 70-130 dB due to two mountain barriers. The main building location, blocked by one mountain, showed propagation loss of 60-90 dB. The viewing platform, with line-of-sight to the receiving antenna and no obstructions, exhibited near free-space propagation characteristics with losses of approximately 60-90 dB.

[Figure 4: see original paper]

4. Electronic Device Interference Analysis

Using the propagation loss measurements as a reference, we evaluated the potential EMI to FAST from sample devices operated in the main building, electronic laboratory, and viewing platform. The microwave chamber test results, expressed as electric field strength, were converted to spectral power flux density (pfd) for comparison with FAST's interference protection threshold. The conversion formula, based on ITU-R RA.769 and ITU-R P.525-2, is:

$$pfd = E - L - 145.8 + 10 \log(BW)$$

where E is the electric field strength in dB V/m, L is the propagation loss, and BW is the bandwidth.

4.1 Interference at Main Building

As shown in Figure 5, when devices are used at the main building, the mobile phone produces interference across 70 MHz-3 GHz. Its photography function exceeds the telescope limit by approximately 20 dB, while dialing exceeds the limit by over 10 dB. The iPad generates relatively minor interference, approximately 10 dB below the limit at 300 MHz. The digital camera's photography function creates interference approaching 40 dB above the limit, while standby mode produces interference near 25 dB above the limit. These results indicate that operation of these devices in the main building will interfere with FAST observations.

[Figure 5: see original paper]

4.2 Interference at Electronic Laboratory

Figure 6 shows that device usage near the electronic laboratory produces interference patterns similar to the main building for frequencies below 1 GHz. However, in the 1-1.5 GHz range, interference is significantly stronger than at the main building, with mobile phone emissions exceeding the limit by approximately 30 dB. Tablet interference exceeds 20 dB, while digital camera photography produces interference of about 10 dB above the limit and standby mode approximately 20 dB above.

[Figure 6: see original paper]

4.3 Interference at Viewing Platform

At the viewing platform (Figure 7), sample devices produce substantially higher interference. Across 700 MHz-3 GHz, mobile phone interference exceeds the limit by more than 40 dB, tablet interference approaches 40 dB, and digital camera interference exceeds 70 dB.

[Figure 7: see original paper]

5. Conclusions and Recommendations

Based on measurements of electromagnetic radiation from tablet, mobile phone, and digital camera samples, combined with on-site propagation loss measurements from key visitor areas to the telescope center, we have evaluated the potential interference from these devices. The analysis reveals that all tested devices produce varying degrees of interference to FAST.

To protect telescope operations and scientific productivity, we recommend implementing the following measures for visitor electronic device management:

1. Restrict visitors from carrying electronic devices into activity areas near the telescope
2. Permit only mechanical optical cameras (which produce no electromagnetic radiation) for photography
3. Establish a visitor center outside the quiet zone in coordination with local authorities
4. Implement targeted site management policies, such as providing secure storage for visitor electronics

These measures will prevent electromagnetic interference from visitor devices and ensure the integrity of FAST observations.

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