The BRITE Space Telescope: High-Precision Photometry of the Brightest Stars

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The BRITE Constellation

- 4 Satellites built on SFL’s 20x20x20cm Generic Nanosatellite Bus (GNB)
- Launch of the first satellites in 2008
- BRITE-Constellation’s goal: To study the most luminous stars using precise differential photometry
- Observe stellar oscillations with periods of days to weeks
BRITE Photometer

- 14 Mpixel CMOS detector
- 5 lens elements
- External aperture stop optics design
- 24° field of view
- 70 mm focal length
- 30 mm aperture
- Will use a red or blue nearly square filter
Variability of Luminous Stars

- Magnetic field variations
- Density variations
- Internal rotation
- Constrain Surface Convection models
# Driving Requirements for BRITE

<table>
<thead>
<tr>
<th>Mission Requirement</th>
<th>Minimum Scientific Requirement</th>
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</thead>
<tbody>
<tr>
<td>Visual Magnitude Limit</td>
<td>+3.5</td>
</tr>
<tr>
<td>Differential Photometry Error per Observation</td>
<td>&lt; 0.1%</td>
</tr>
<tr>
<td>Error of Amplitude Spectrum</td>
<td>&lt; $2\times10^{-5}$ (20 ppm)</td>
</tr>
<tr>
<td>Length of Observational Campaign</td>
<td>&lt; 100 days</td>
</tr>
<tr>
<td>Duty Cycle of Observations</td>
<td>&lt; 15%</td>
</tr>
<tr>
<td>Duration of the Mission</td>
<td>&gt; 2 years</td>
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<tr>
<td>Potential Observational Regions</td>
<td>All parts of the sky with exclusion zones around the Sun, Earth, &amp; Moon</td>
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BRITE Constellation

- Four satellites – two using a red filter, two using a blue filter
- Observe each star with two different colour filters without moving parts
- Increase the duty cycle of observation
- Increase number of stars of observed
Generic Nanosatellite Bus

- 5 kg mass
- 5.6 W power nominal
- Three orthogonal reaction wheels
- S-Band downlink: 32 kbps
- UHF uplink: 4 kbps
- Three ARM7 processors
- Dual tray design
- Central volume for payload
Photometer Design: Optics

- External stop design
- Different designs for red and blue filters
Photometer Design: Structure
Photometer Design: CMOS Detector

IBIS4-14000 (Cypress)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Typical Value</th>
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<tbody>
<tr>
<td>Imager size</td>
<td>35x24 mm</td>
</tr>
<tr>
<td># of pixels</td>
<td>4560x3048</td>
</tr>
<tr>
<td>Pixel size</td>
<td>8x8 μm²</td>
</tr>
<tr>
<td>Full well charge</td>
<td>65000 e⁻</td>
</tr>
<tr>
<td>Dark current</td>
<td>223 e⁻/s</td>
</tr>
<tr>
<td>Power</td>
<td>&lt; 176 mW</td>
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</tbody>
</table>
Photometer Design: Electronics

- 32 MB SDRAM
- 16.6 cm A/D Converters (4)
- IBIS CMOS Imager

5 cm
Conclusion

- BRITE Constellation is the first nanosatellite constellation astronomy mission
- A custom built CMOS based photometer on BRITE will provide the combination of low power and high precision required for the mission
- Complements the MOST mission by extending our knowledge of the fundamental parameters of luminous stars.
Sun Stare Analysis

- In FEM detector is isothermal to a few degrees
Sun Stare Analysis

• Assuming a uniform detector temperature:

\[ T_{CHIP} = \left[ T_s^4 + \frac{\pi D_A^2 G_S C_L C_F \alpha}{4\sigma (\varepsilon_D A_D + \varepsilon_P A_P)} \right]^{1/4} \]

• Average temperature = 54°C (Steady state)
  - Agrees with FEM
  - No door required
Availability of Stars

24x19.2° Rectangular Field of View

16x10° Rectangular Field of View

Number of Stars

16 14 12 10 8 6 4 2 0
BRITE Target Stars

+3.5 Stars inside 24 degree FOV
Stellar Life Cycle
BRITE Control

boundary window

stability

repeatability zone