Active magnetic attitude control algorithms for CXBN-2 CubeSat

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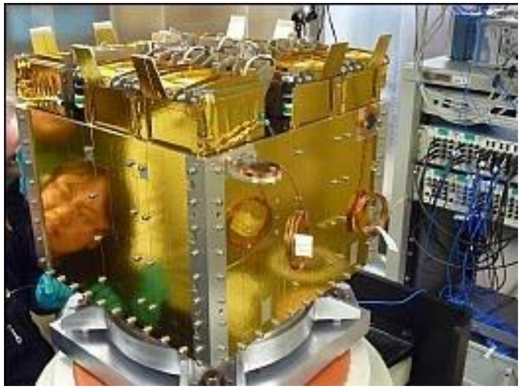
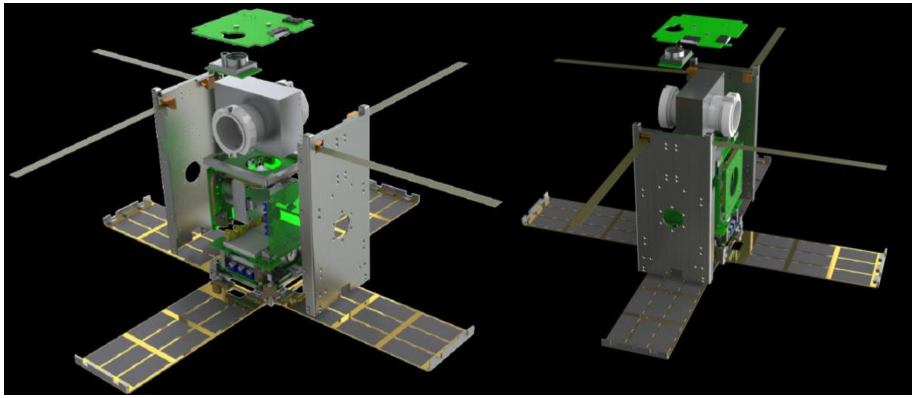
CXBN-2 satellite





- Cosmic X-Ray Background in the 30-50 keV range
- 10/1 degrees attitude knowledge for primary/sec mission
- Possibly even celestial sphere coverage, maximizing overall science data
- Sensor can withstand bright sources, however loosing data

Main goal and problem statement

The most simple attitude control (both hardware and software) for a given scientific mission

- Hardware
  - Passive systems: incapable to fulfill scientific goals
  - Wheels: mass, price, power
  - Magnetorquers: an excellent choice!
- Software/algorithms: the simplest control loop available

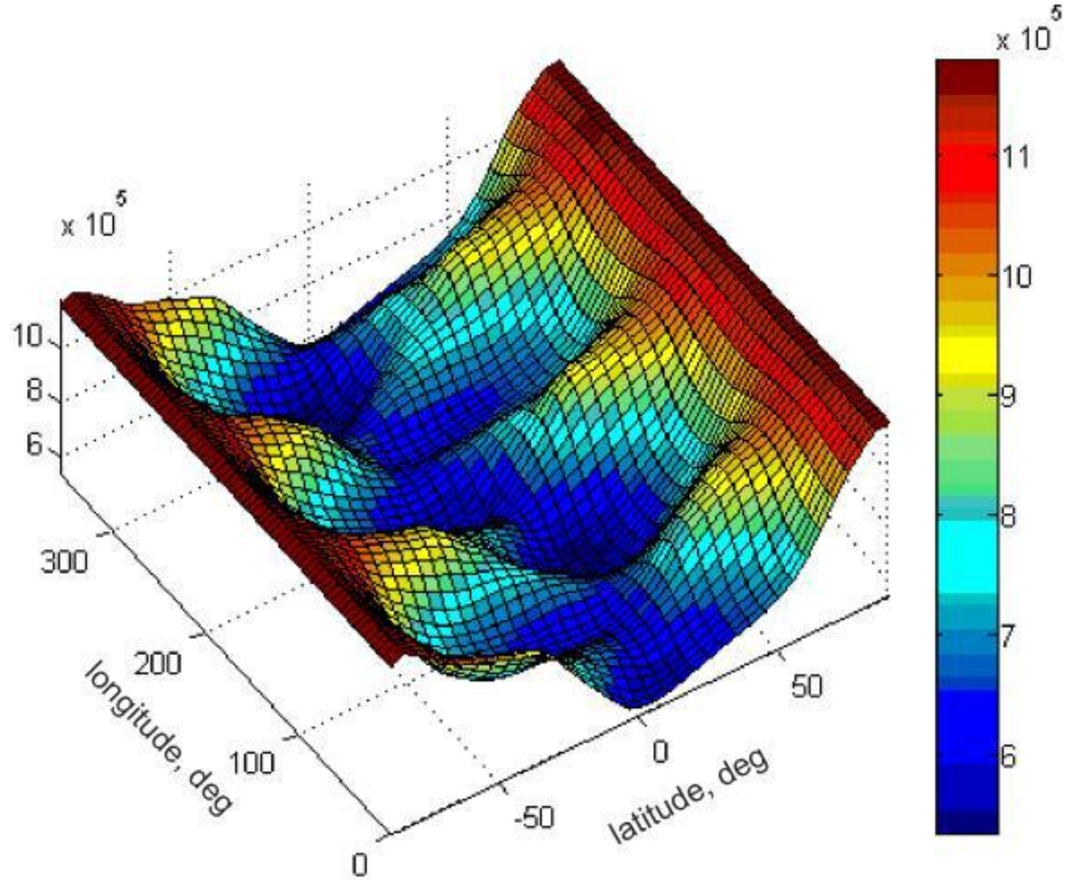
Control schemes

- Spin-stabilized satellite
  - Regular spin axis rotation
  - Spin-stabilization with Earth avoiding. Spin axis is always directed roughly to the local vertical
  - Spin-stabilized with solar panels charging and Earth avoiding
- Free-flying satellite with speed control

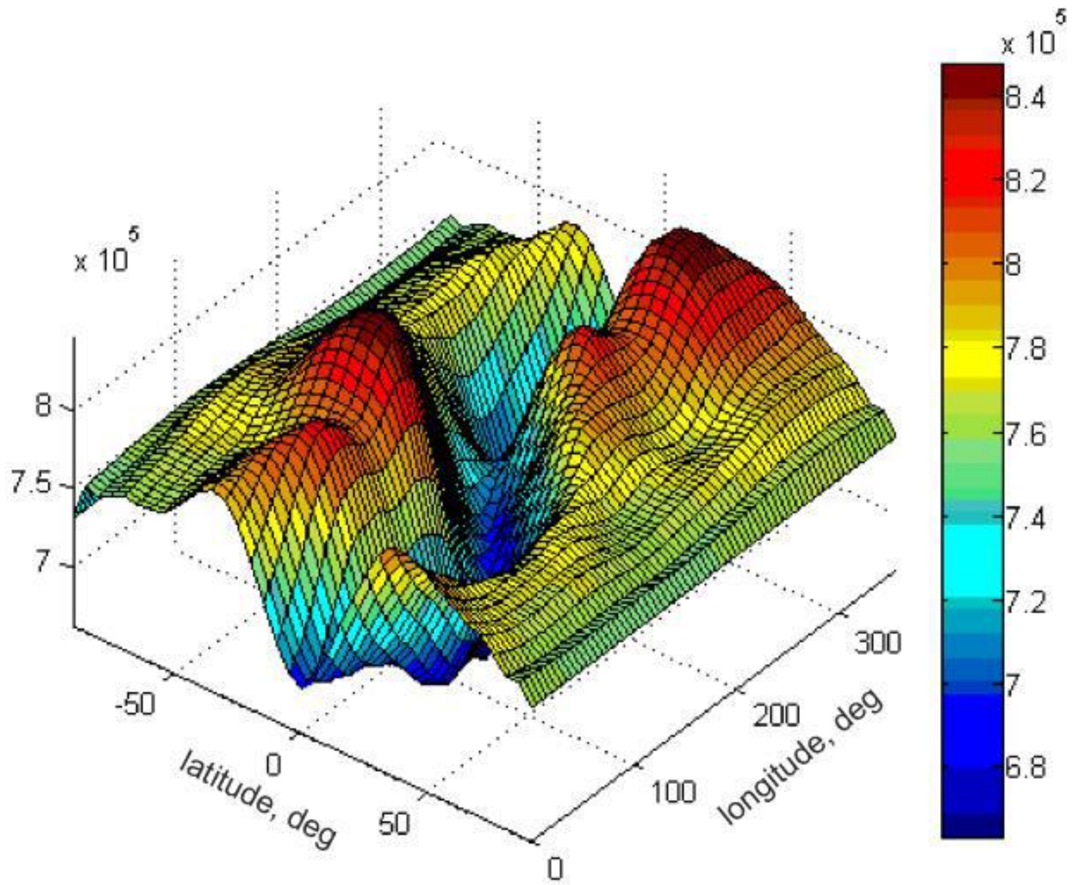
Control laws

- Spin stabilized
  - Nutation damping $\mathbf{m}_{nut} = -k_{nut}\left(\frac{d\mathbf{B}}{dt}\mathbf{e}_3\right)\mathbf{e}_3$
  - Spinning $\mathbf{m}_{spin} = k_{spin}\left(B_2, -B_1, 0\right)^T$
  - Reorientation $\mathbf{m}_{or} = \left(0, 0, k_{or}\left(\Delta\mathbf{L}\cdot\left[\mathbf{e}_3 \times \mathbf{B}\right]\right)\right)^T$
- Speed control $\mathbf{m} = \pm k_{damp}\frac{d\mathbf{B}}{dt}$

Continuous rotation one year scientific data



Free flying one year scientific data



Control schemes comparison

	Overall sets/year	Min. sets	Max. sets	Dipole moment, Am^2
Spin stabilization	31.346.066 (100.3%)	534.320 (80.6%)	1.177.844 (139.0%)	0.05
SS with Earth avoiding	31.875.472 (102.1%)	266.819 (40.2%)	1.106.402 (130.6%)	0.15
SS, Earth avoiding, charge	32.244.917 (103.3%)	641.783 (96.8%)	1.207.403 (142.5%)	0.15
Free flying	31.229.476 (100%)	663.068 (100%)	847.258 (100%)	0.05

Other factors

	Spin stabilized	Free flying
Sensors	Magnetometer+? (three axis attitude knowledge)	Magnetometer
Data quality	Continuous control, worse attitude knowledge	Rare control
Polar region coverage	Good	Poor, but data here is spoiled nevertheless
Power consumption	Continuous control, maybe greater current	Less current and control time

Conclusion

- Simplest active control algorithm can fulfill mission goals
- Simple control may have “hidden” advantages
- Maybe even simpler passive system? One more presentation!