Quantum Atomic Rydberg Radiometer for Earth Measurements (QuARREM)

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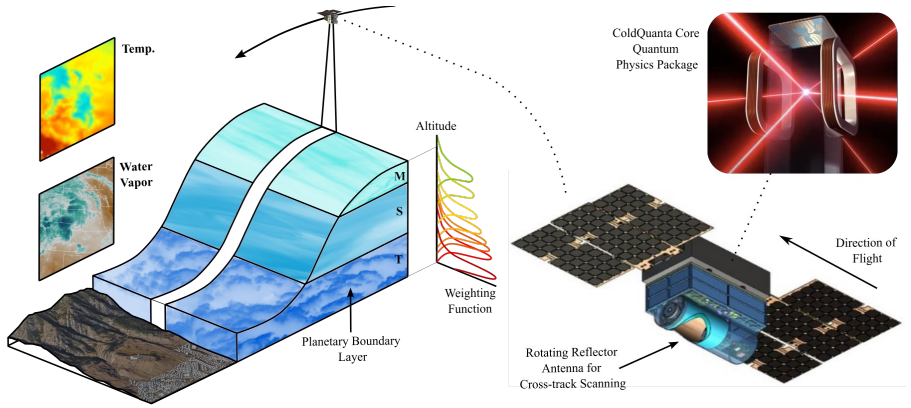
Objective

Develop an unprecedented, hyperspectral quantum microwave radiometer for Planetary Boundary Layer science applications to initially operate in the 50 to 60 GHz (V-band) range below the oxygen spectral resonance centered near 60 GHz for determination of the atmospheric vertical temperature profile.

To be highly capable as a hyperspectral, low SWaP radiometer by:

- Minimizing channel bandwidth and increasing channel quantity by using a single atomic receiver
- Enabling detection sensitivity near or at the quantum limit
- Adapting post-launch to a variety of narrow-band channels
- Facilitating on-board, post-launch self- and absolute-calibration within each measurement
- Constantly viewing target scene for longer integration time
- Reducing essential, in-path RF subsystem complexity



A QuARREM-based microwave radiometer flight concept with a ColdQuanta quantum sensing platform as the core “backend microwave electronics”. The concept would operate in a cross-track scanning mode using a rotating reflector antenna to satisfy spatial sampling requirements for free atmosphere, PBL, and surface imaging science.

Approach

Demonstrate incoherent RF blackbody detection in a quantum system by:

- Expanding modeling capabilities for system function and enhancements
- Assembling an optics/RF testbench for incoherent microwave temperature measurement and characterizing the radiometric performance benefit
- Fabricating titanium-glass atomic vapor cells to function as the analog backend sensor
- Generating calibration procedures and assessing absolute-calibration potential

Co-Is/Partners: Eric Bottomley, ColdQuanta; Dr. Lauren Aycock, Sean Geiger, Ball Aerospace

Key Milestones

• Preliminary modeling extension	06/23
• Test-bench build with upconverted noise chain	09/23
• Experimental / theory assessment of frequency targets using commercially available vapor cells	12/23
• Build of Package V1	12/23
• Test bench rearrangement to include blackbody target	03/24
• Validation of frequency and temperature targets in Package V1	09/24
• Build of Package V2	12/24
• Upgrade the testbench to include dual-fluorescence needs	06/25
• Absolute calibration validation and external validation of Package V2 to a blackbody target	09/25
• Comparison study to classical microwave radiometers	03/26

$TRL_{in} = 2$ **$TRL_{current} = 2$**