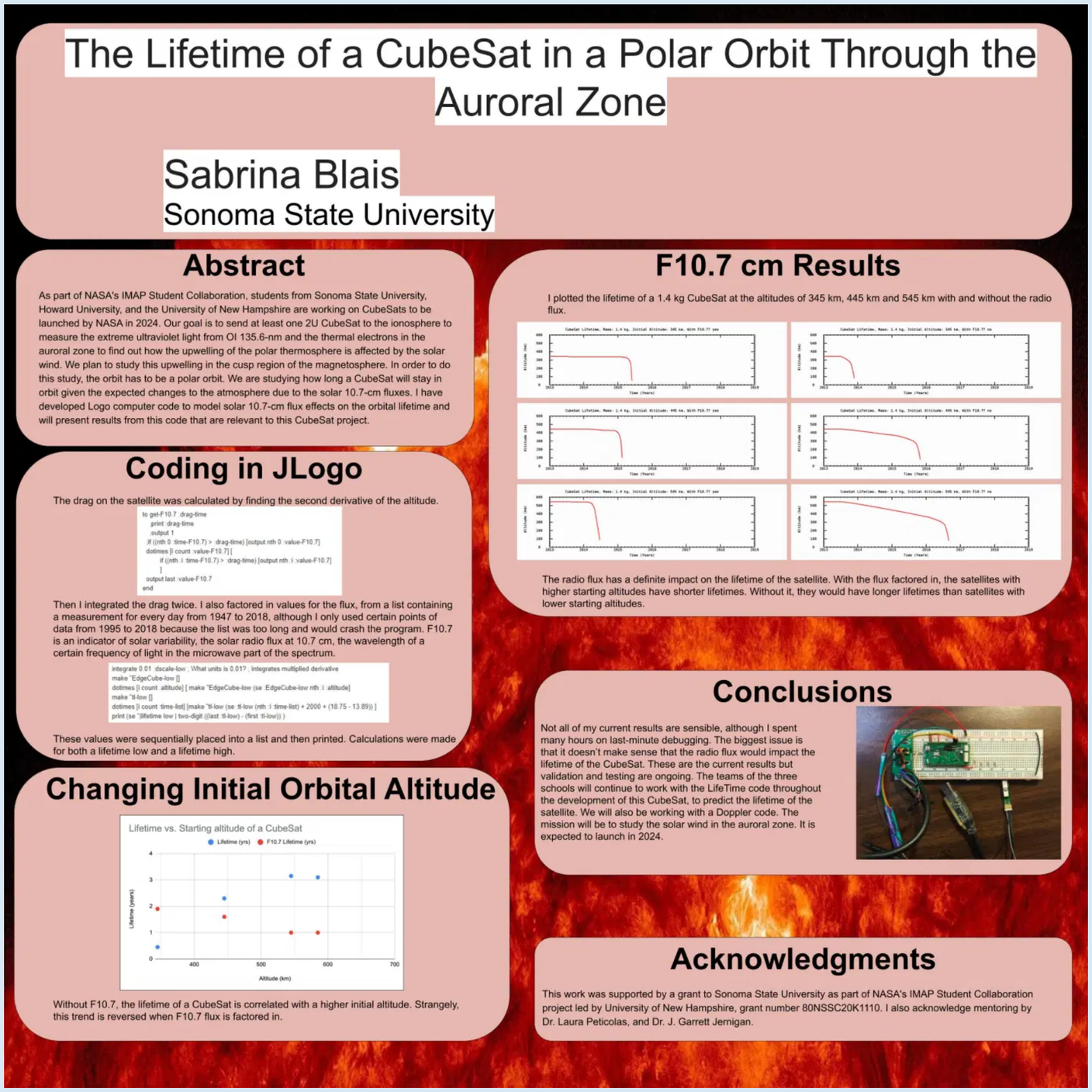

The Lifetime of a CubeSat in a Polar Orbit Through the Auroral Zone

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Abstract

As part of NASA's IMAP Student Collaboration, students from Sonoma State University, Howard University, and the University of New Hampshire are working on CubeSats to be launched by NASA in 2024. Our goal is to send at least one 2U CubeSat to the ionosphere to measure the extreme ultraviolet light from OI 135.6-nm and the thermal electrons in the auroral zone to find out how the upwelling of the polar thermosphere is affected by the solar wind. We plan to study this upwelling in the cusp region of the magnetosphere. In order to do this study, the orbit has to be a polar orbit. We are studying how long a CubeSat will stay in orbit given the expected changes to the atmosphere due to the solar 10.7-cm fluxes. I have developed Logo computer code to model solar 10.7-cm flux effects on the orbital lifetime and will present results from this code that are relevant to this CubeSat project.

Coding in JLogo

The drag on the satellite was calculated by finding the second derivative of the altitude.

```
to get-F10.7 :drag-time
  ;print :drag-time
  output 1
  if ((nth 0 :time-F10.7) > :drag-time) [output nth 0 :value-F10.7]
  dotimes [i count :value-F10.7] [
      if ((nth :i :time-F10.7) > :drag-time) [output nth :i :value-F10.7]
      ]
  output last :value-F10.7
end
```

Then I integrated the drag twice. I also factored in values for the flux, from a list containing a measurement for every day from 1947 to 2018, although I only used certain points of data from 1995 to 2018 because the list was too long and would crash the program. F10.7 is an indicator of solar variability, the solar radio flux at 10.7 cm, the wavelength of a certain frequency of light in the microwave part of the spectrum.

```
integrate 0.01 :dscale-low ; What units is 0.01? ; integrates multiplied derivative
make "EdgeCube-low []
dotimes [i count :altitude] [ make "EdgeCube-low (se :EdgeCube-low nth :i :altitude]
make "tl-low []
dotimes [i count :time-list] [make "tl-low (se :tl-low (nth :i :time-list) + 2000 + (18.75 - 13.89)) ]
print (se "|lifetime low | two-digit ((last :tl-low) - (first :tl-low)) )
```

These values were sequentially placed into a list and then printed. Calculations were made for both a lifetime low and a lifetime high.

Changing Initial Orbital Altitude

Without F10.7, the lifetime of a CubeSat is correlated with a higher initial altitude. Strangely, this trend is reversed when F10.7 flux is factored in.

F10.7 cm Results

I plotted the lifetime of a 1.4 kg CubeSat at the altitudes of 345 km, 445 km and 545 km with and without the radio flux.

The radio flux has a definite impact on the lifetime of the satellite. With the flux factored in, the satellites with higher starting altitudes have shorter lifetimes. Without it, they would have longer lifetimes than satellites with lower starting altitudes.

Conclusions

Not all of my current results are sensible, although I spent many hours on last-minute debugging. The biggest issue is that it doesn't make sense that the radio flux would impact the lifetime of the CubeSat. These are the current results but validation and testing are ongoing. The teams of the three schools will continue to work with the LifeTime code throughout the development of this CubeSat, to predict the lifetime of the satellite. We will also be working with a Doppler code. The mission will be to study the solar wind in the auroral zone. It is expected to launch in 2024.

Acknowledgments

This work was supported by a grant to Sonoma State University as part of NASA's IMAP Student Collaboration project led by University of New Hampshire, grant number 80NSSC20K1110. I also acknowledge mentoring by Dr. Laura Peticolas, and Dr. J. Garrett Jernigan.