Haptic Arduino and CME Mass Calculation

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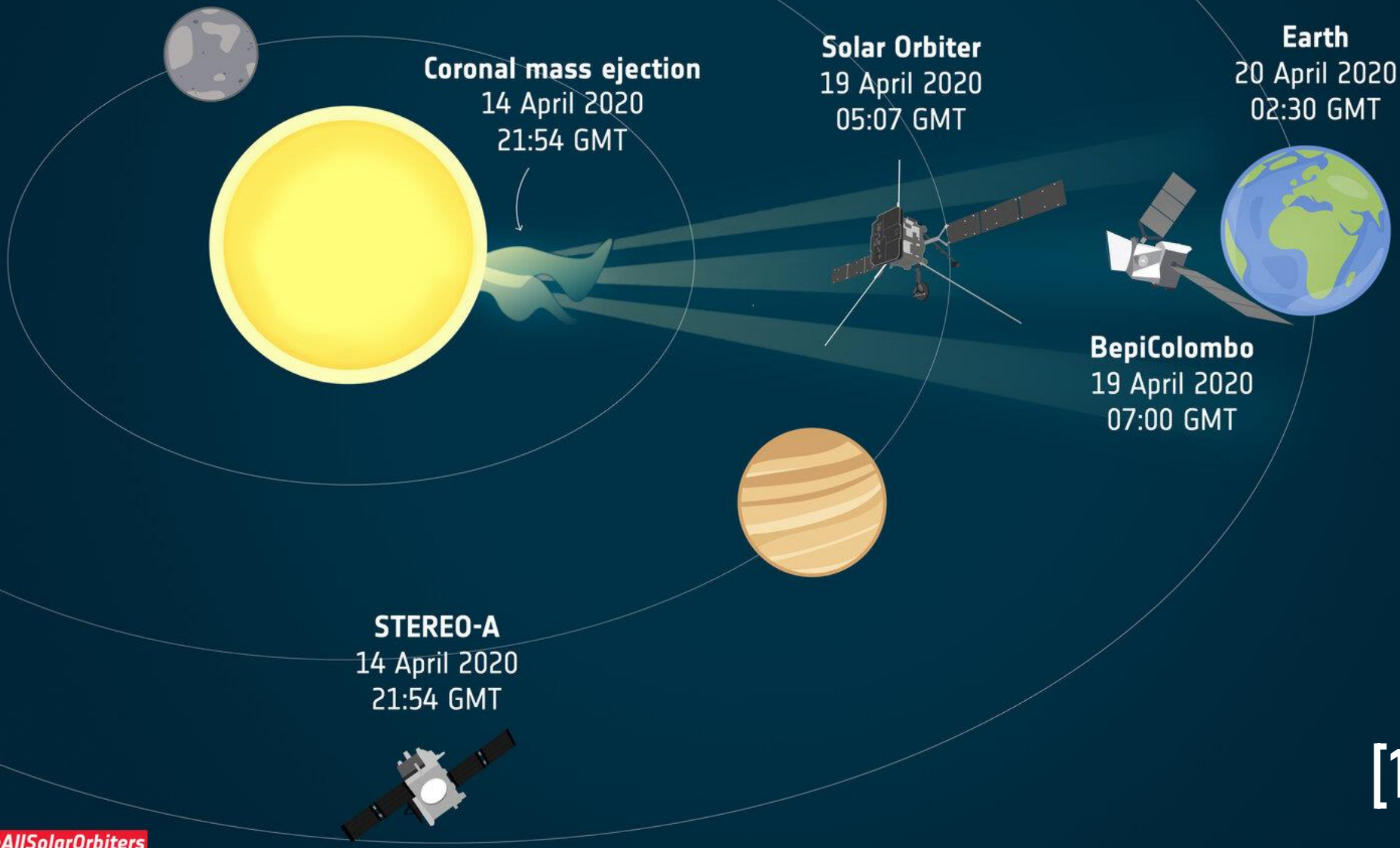
Coronal Mass Ejection (CME)

- Ejection of solar materials -> charged particles
- Particles affected by electromagnetic space environment -> Thomson scattering
- Mass calculation depends on angle.

MULTIPOINT DETECTIONS OF A CORONAL MASS EJECTION



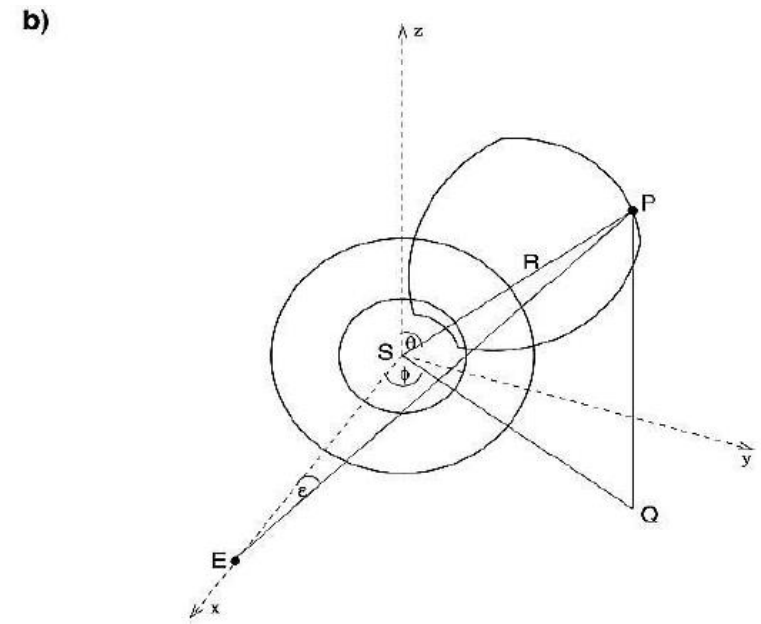
[1]

#SolarOrbiter #WeAreAllSolarOrbiters

CME Mass Calculation: Geometry [2]

- Data: coronagraph from LASCO (Hα)
- P: CME edge; Q: observer -> angle: $\varepsilon \sim R$
- mass is localized at plane of sky -> Howard et al. [3] corrected projection effect
- Sky-plane (all CME), θ=0, defines $sin\Omega = \frac{1}{R}$
- and so

$$sin\Omega = \frac{cos\theta}{R_0}$$



A schematic diagram of CME [2]

CME Mass Calculation: Thomson Scattering [2]

$$m = \frac{B_{obs}}{B_e(\theta)} \times 1.97 \times 10^{-27}\, Kg$$

- Be(θ) is calculated using four Thomson Scattering formulas.
- Bobs is calibrated using the images obtained.

$$A\,(R) = cos\Omega\, sin^2\Omega$$

$$B\,(R) =$$

$$-\frac{1}{8}\left[\,1 - 3\,sin^2\Omega - cos^2\Omega\,\left(\frac{1+3sin^2\Omega}{sin\Omega}\right)\ln\left(\frac{1+sin\Omega}{cos\Omega}\right)\right]$$

$$C\,(R) = \frac{4}{3} - cos\Omega - \frac{cos^2\,\Omega}{3}$$

$$D\,(R) =$$

$$-\frac{1}{8}\left[\,5 + sin^2\Omega - cos^2\Omega\left(\frac{5-sin^2\Omega}{sin\Omega}\right)\ln\left(\frac{1+sin\Omega}{cos\Omega}\right)\right]$$

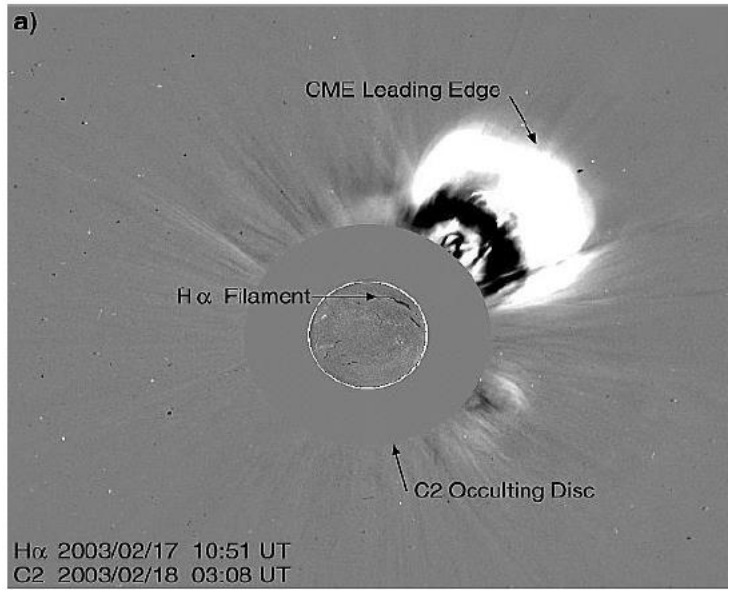
$$B_e(\theta) =$$

$$\frac{\sigma\pi}{2}\left[2\left(C + u(D-C)\right)cos^2\theta\left(A + u(B-A)\right)\right]$$

Working on Bobs

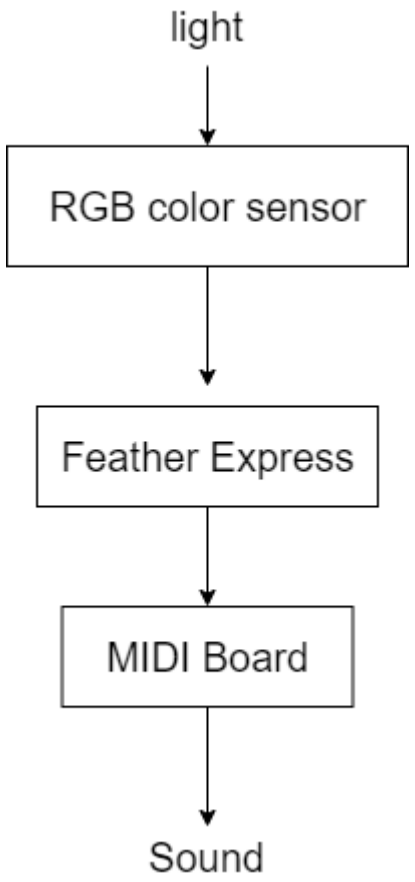
- Related to area and pixelation (given by image)

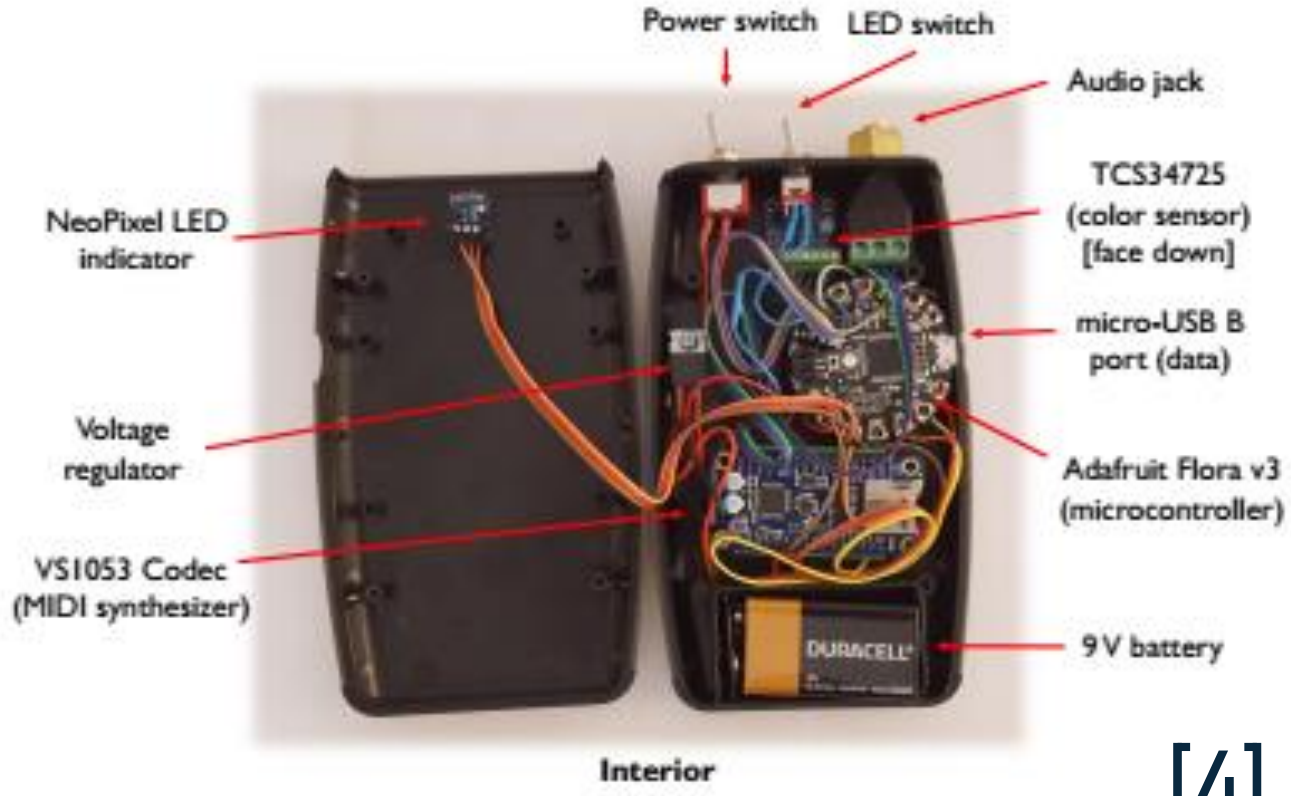
- Sonification (Diaz-Merced) to remeasure Bobs, using Orchestar



LASCO, C2 image with a Hα superimposed [2]

Orchestar by Hyman et al. (2019)





[4]

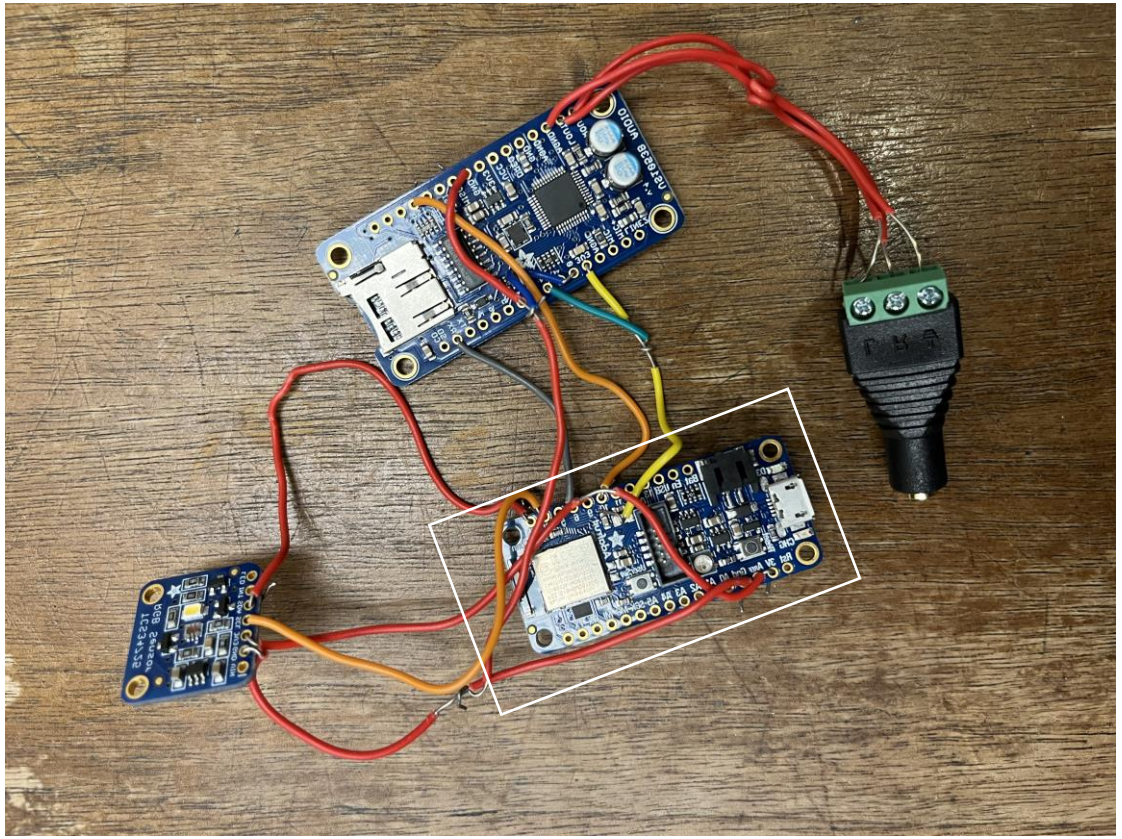
Audio to Haptic

- Accessibility
- Aid with sound
- Decipher data from noises

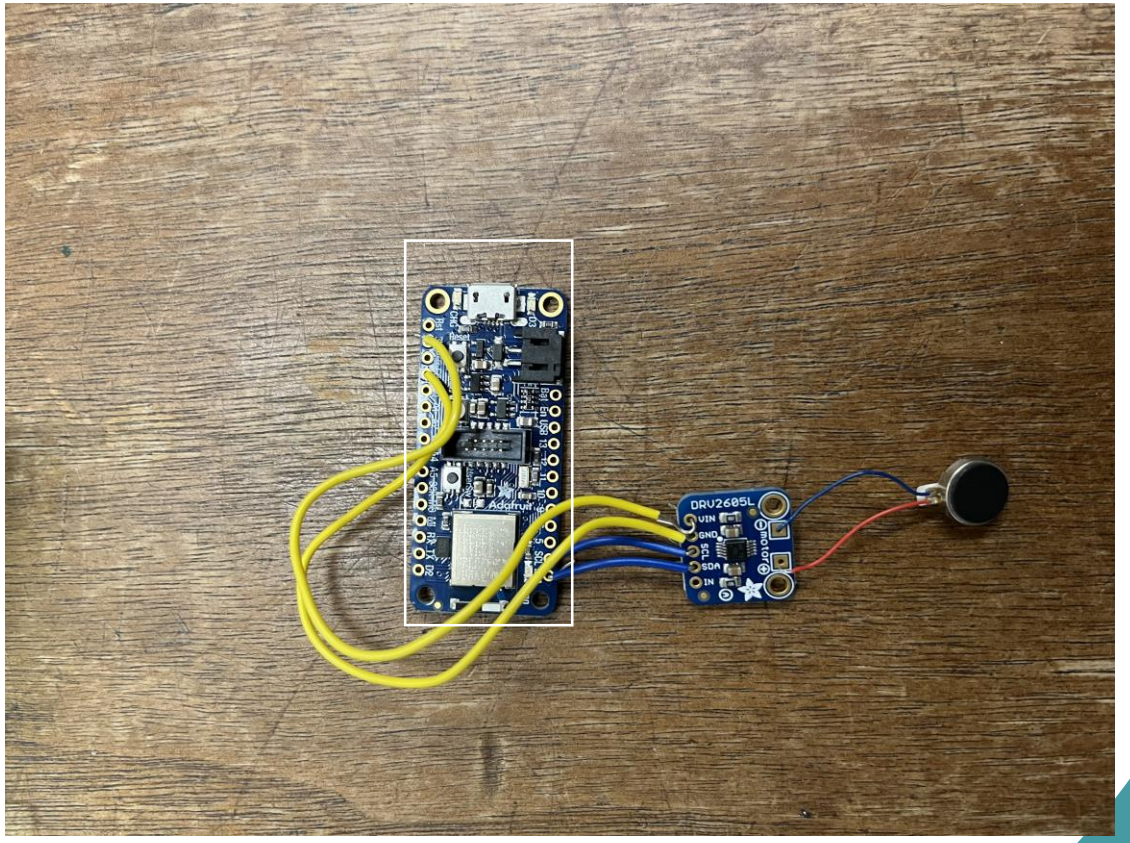
  Cardiff University: Black Hole Hunter [5]

  https://ep.ego-gw.eu/SonificationTraining/HomePage.html

Haptic Arduino (in Progress)

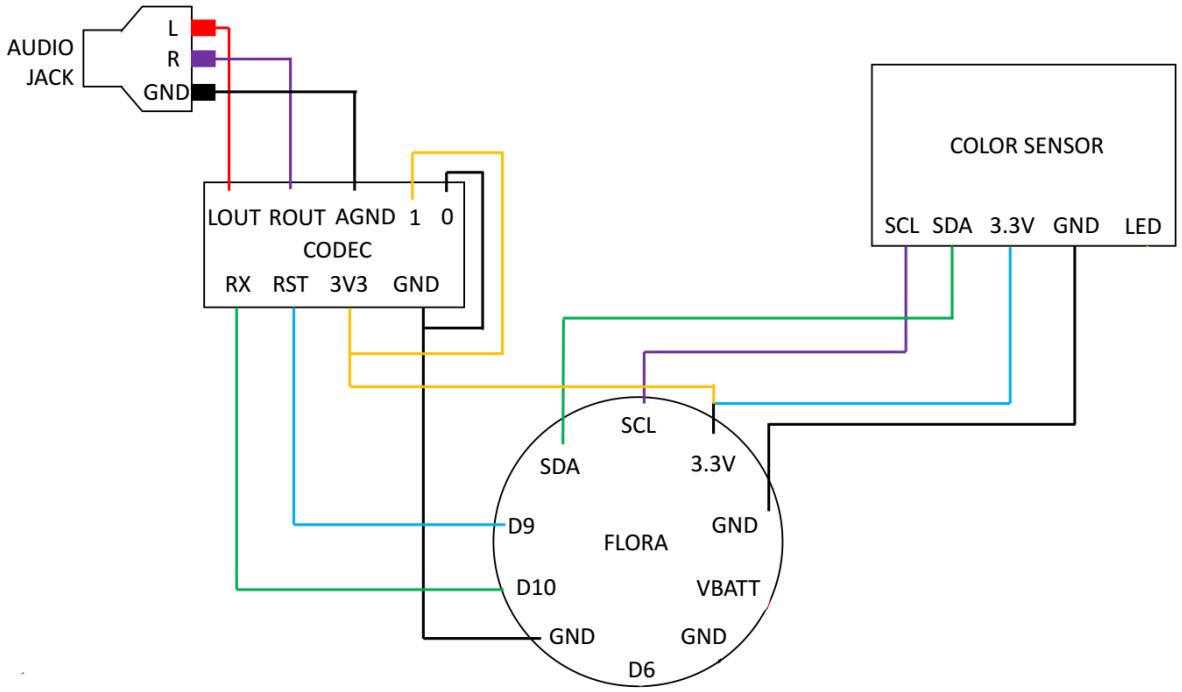


Color Arduino

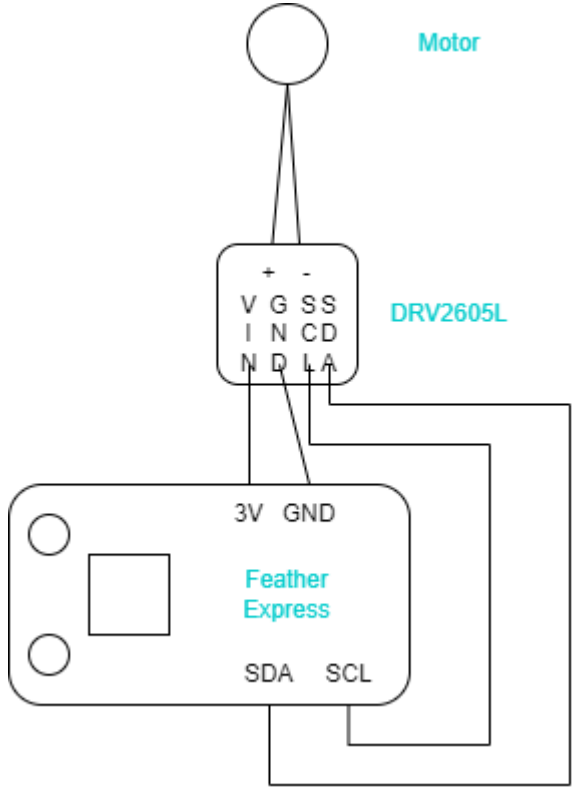


Motor Arduino

Wiring



Color Arduino [4]



Motor Arduino

Dual role BLEUART

[5]

- Bridge-> transfer messages back and forth
- Advertise, scan, callback, send data

Current Progress

- Connected the two microcontrollers via Bluetooth dual role, and the motor is vibrating upon connection
- Still need to transfer data, and set up corresponding waveforms

References

[1] “Multipoint Detections of a Coronal Mass Ejection.” ESA, *The European Space Agency*, 2020, https://www.esa.int/ESA_Multimedia/Images/2020/12/Multipoint_detections_of_a_coronal_mass_ejection.

[2] AL OBAİD, Mays. “Mass Determination of Coronal Mass Ejection by Thomson Equations.” *Acta Materialia Turcica*, 2020, 4(5), 1-8.

[3] Howard, T. A., D. Nandy, and A. C. Koepke, “Kinematic properties of solar coronal mass ejections: Correction for projection effects in spacecraft coronagraph measurements”, *J. Geophys. Res.,* 2008, 113, A01104, doi:10.1029/2007JA012500.

[4] Hyman, Soley, et al. “Orchestar: Teaching the Color/Temperature Relation through Sound.” *NASA/ADS*, 2019, https://ui.adsabs.harvard.edu/abs/2019AAS...23410403H/abstract.

[5] Black Hole Hunter, *Cardiff University Gravitational Physics Group*, https://blackholehunter.org/.

[6] Dual Roles BLEUART, *Adafruit*, https://learn.adafruit.com/bluefruit-nrf52-feather-learning-guide/dual-roles-bleuart.