My research has been focused on the combined effects of chemistry and dynamics in protoplanetary disks. I have developed two different models to examine how dust grain evolution can feedback on the observable chemistry of the disk and how the presence of a giant planet can affect dust transport across the disk.

Observations of protoplanetary disks have shown that CO abundances tend to be 10-100× lower than ISM values. To address this issue, I created a new combined dust growth and chemical model `CANDY`[1] (Chemistry ANd DYnamics), which solves disequilibrium chemistry in the gas and ice while simultaneously evolving the dust population to account for dust growth and settling. Using this combined approach, we showed that dust growth leads to both trapping of CO in ice and an increase in photodestruction of CO, increasing the C/O of the gas while decreasing CO abundances. These combined effects resulted in a CO depletion of up to 100× below ISM values in 1 Myr, matching disk observations, while simultaneously raising the C/O of the gas to unity.

These results were published in *The Astrophysical Journal* (Van Clepper et al. 2022, *ApJ*, 927, 206) and are cited to explain the need for coupled dust evolution with gas phase chemistry to explain observed CO abundance and C/O in observed disks. Currently, this model is being expanded to examine the oxygen isotopic evolution of the solar system. In a work currently in prep, we show that disk processing is insufficient to explain the observed meteorite record, favoring inheritance of isotopically heavy water from the molecular cloud.

More recently, I have been studying the transport of dust across planet induced gaps. In our solar system, it is often assumed that Jupiter separated the inner disk and outer disk into two distinct reservoirs. I examined this assumption by creating a new method to combine 3D hydrodynamic disk simulations with Monte Carlo tracer particles to track the transport of dust grains in a structured disk. In work now published in *The Astrophysical Journal* (Van Clepper et al. 2025, *ApJ* 980, 201), I showed that for moderately turbulent disks, small dust grains ($\mathrm{St} \lesssim 10^{-3}$) filter through the gap even after the planet mass exceeds the pebble isolation mass. Accurate modeling of this grain filtering is necessary for interpreting volatile delivery to the inner disk, and the results of this work have been cited in both observational and theoretical work examining the consequences of these leaky disks.

In addition to confirming the results of previous 1 and 2D models of grain filtering, I showed that these grains follow the accretion flows past the planet, lofting near the surface of the disk via the meridional flows. By combining this grain filtering with radiative transfer modeling, I have shown that grains in the pressure bump are efficiently lofted to the surface of the disk. In this region, temperatures are higher due to irradiation from the star and volatile ices on the grain surface can be sublimated and accreted onto the atmosphere of the growing giant planet. This work is currently in review for publication in *The Astrophysical Journal Letters* and may explain metallicity enhancements in giant planets, including Jupiter.

In the work I propose to do as a 51 Pegasi b fellow, I will expand upon all of these projects to continue to explore the combined effects of grain growth and dynamics with gas-phase chemistry. With the majority of the methodology and analysis tools already in hand, I will be able to quickly begin the proposed projects. As a result of my previous work with astrochemistry, cosmochemistry, and exoplanet communities, I also am well equipped to place these results within the larger interdisciplinary field of planet formation.

[1] https://github.com/ervc/newcandy