**Proposal Outline:**

**Section 1:** Facts, Problem & Summary paragraph

a) What is the descriptive heading? **The Need for New Milky Way Halo Models and the Role of the Magellanic Clouds**

1. 1-2 fact-based paragraphs:
2. State the fact leading each paragraph

Astronomy has entered an era of high precision astrometry. Data from the *Hubble Space Telescope (*HST*),* the *James Webb Space Telescope (*JWST*),* is important.

1. Provide At least one reference per fact/paragraph.

Examples of high precision astrometry data that has been taken.

1. What is the nuanced conclusion for each paragraph/fact?

Models + these awesome data = cool stuff !

When combined with detailed models of the MW’s halo potential, such measurements become high- precision tools to constrain the dark matter mass distribution about the MW and compute accurate orbital histories of satellites/streams, revealing the MW’s assembly history.

1. Problem paragraph:
2. What is “the problem” statement?

Thus, the Clouds are not small galaxies . massive satellites will *contribute* to the dark matter distribution of the MW,

1. Why is it critical to answer now? [ nuanced conclusion ]

This effect has not yet been accounted for in existing models of the MW, but has the potential to perturb the kinematics of *all* tracers of the halo potential.

1. The last paragraph:
2. What is the proposal? (identify key component)

Create high res Nbody models --> key component

Target--> LMC+SMC+MW Halo

We propose to create needed N-body models of the LMC+SMC+MW system with mass resolution 3 orders of magnitude higher than any created to date (109 particles).

1. Why HST/JWST?

Directly using HST proper motions of the Clouds

interpret existing and upcoming astrometric data sets from HST*,* JWST

1. Does this advance HST/JWST science goals? (Or goals of the observatory you chose)
   * Which **key science goals** of HST/JWST does your proposal connect to ?
   * JWST: <https://webb.nasa.gov/content/science/index.html>
   * HST: <https://www.stsci.edu/hst/about/key-science-themes>

**Building blocks of the Universe**

Theory and observations, including from HST, are used to disentangle the relationship between galaxies and the weakly interacting dark matter

**Section 2:** The Problem & Motivation/Narrative of the proposal

Identify a descriptive heading that states the problem

**The Magellanic Clouds will Perturb the Orbits of all Halo Tracers**

State why solving this problem advances the subfield. : nuanced conclusion Neglecting the LMC when modeling the orbits of satellites and streams will force *artificial* shifts in the gravitational potential, which can be misinterpreted as intrinsic properties of the MW’s halo.

1. Identify the “key component” missing to solve the problem.:
2. Missing in existing orbit integration schemes is the response of the MW’s halo to the presence of the Clouds and the distortions to their dark matter distributio
3. List relevant references -- Gomez etc. supporting facts for the problem.
4. Outline a figure to illustrate the problem (can be in words, a sketch)

Illustrate an orbit that is perturbed by the LMC and one that is not. To illustrate the scope of the problem -- mass of the LMC perturbs things.

**Section 3:** Describe the Target (setting the stage for generating the “Key Component”)

1. What are you targeting ? (imaging/spectra/archival data of **what astronomical object**, or **what physical mechanism/ simulations/data** **set** )

**Combined LMC+SMC+MW Dark Matter Halo**

b). State why is the target critical to solving the “problem”? 3D dark matter distribution of the combined system will *not be ellipsoidal (oblate, prolate or triaxial),* as conventionally assumed

This is a good target to answer the problem (need for complex models of dark matter distributions) because initial studies show that the combined system is weird!

1. State the suitability of target 🡪 Feasibility with “key component”:

For GO: Feasibility of HST/JWST observations (justify HST/JWST usage)

For AR/Theory: Identify existing/future HST/JWST data sets (proposal #)

Preliminary work is presented to illustrate that the target makes sense

1. Outline a figure that explains the chosen target (e.g. illustrate the target and connection to “key component" and/or “problem”). (can be in word, a sketch)

Figure from preliminary work that illustrates the target is messed up and therefore a feasible target to model and a good choice to answer the problem.

There is a good reason to expect that there will be interesting outcomes from this proposal based on the presented feasibility argument in this section.

**Section 4:** The Strategy: HST/JWST + Target Solves the Problem (Generate the “Key Component”)

a)Explain the strategy to generate the key component:

For GO: describe the proposed observations \*briefly/succinctly\*

For AR/Theory: describe \*briefly\* the analysis method/proposed **usage** of simulations/codes and relation to existing/future HST/JWST data sets.

High res Nbody simulations

compute SCF expansion at each snapshot of the simulations

interpolate the results.

List of GO programs that will be utilized with the new data products.

b) Explain the data products of the program (tangible outcomes).

This is the main data product: The interpolated coefficients are used to analytically reconstruct the density and potential of the combined dark matter distribution (see Fig. 4).

c) Outline a diagram for your strategy (key component + target = solution) (can be in words, a sketch)

Figure : panel 1 (Dark Matter Nbody models +. LMC+SMC+MW). --> Interpolated coefficients == SOLUTION - orbit reconstruction in new potential.

**Section 5:** Importance & Broader Implications

1. What are the big picture implications of the proposed products of your study to your **subfield** and why do they matter? (How will your study advance the subfield?)

**Importance -- we want to know to what extent can we consider the MW to be a Virialized System**

1. How does this study increase the **legacy value** of the observatory?
   * + What **other subfields** are advanced by these observations (GO) or data analysis/code/simulations (AR) ?
     + Do the data products serve the community at large?
     + Techniques, codes that will have legacy value -- enable others to do science.
     + **Extended Applications: The Combined Halo Potential of M31 and M33**
     + Implications for the Andromeda system.