1. Science aim/goal
Establish the interstellar processes that maintain a multi-phase ISM, regulate the transition of gas between phases, and form molecular clouds.

2. (i) Scientific Importance:
The production of stars is a fundamental process that drives the evolution of galaxies over cosmic time. Newborn stars emerge from clouds of molecular gas that are embedded within a dynamic, multiphase interstellar medium (ISM) driven by rotational shear, magnetic fields, and mechanical and radiative feedback from supernovae and massive stars. Understanding the interactions and energy balance between each phase, how molecular clouds condense from the diffuse atomic gas interstellar component and how the rate and yield of stellar production depend on cloud properties are essential requirements to develop a more complete description of star formation and galaxy evolution.
(ii) Measurements Required:
To make significant progress, we require imaging of emission from well-defined tracers of the atomic and molecular gas phases of the ISM. Spectroscopic measurements in the mid- and far-IR are therefore critical since this wavelength regime contains the most important cooling lines (CII, OI, OIII, NII) as well as the H_2 rotational lines at 17 and 28 μm. Imaging of line emission from entire galaxies allows one to evaluate these gas phases with respect to kpc scale structures such as spiral arms, stellar bar potentials while reconnaissance in the Milky Way provides a high spatial resolution view of phase interactions. High spectral resolution is required to separate closely spaced velocity components in the Galactic plane while also providing key velocity information that can constrain theories of molecular cloud formation (Dobbs et al 2014).

The energy balance within the atomic and molecular gas phases is assessed from the measured luminosity of these cooling lines and the accounting of energy input from stars and supernovae. Imaging of galaxies and selected regions of the Milky Way in one or more of these cooling lines along with a census of heating sources provide direct measures of the energy balance within the neutral ISM. With the ability to resolve gas motions, one can evaluate the relative contributions of SNR-driven expanding shells and radiative output from massive stars to the ISM energy budget.

Gravity is an essential component to cloud formation as it acts to accumulate gas over large scales. Perturbations to the local gravitational potential conducive to cloud formation are generated by spiral density waves, the interface of large-scale (~10^2 pc) converging flows, and dense shells of swept up interstellar material.

Spectroscopic imaging of CII emission with high spectral resolution from nearby, face-on spiral disk galaxies would produce the data to evaluate these processes. In connection with H_2 rotational lines, CO and HI 21cm line data, these measurements would quantify the flow of atomic and molecular gas through the spiral potential -- allowing researchers to evaluate the gas velocities predicted by spiral density wave theory in each component, the location of developing molecular clouds (CO and dark H_2) with respect to the atomic material (CII and HI 21cm line) and downstream sites of star formation. One could also assess the amount of H_2 gas located within interarm regions that may also contribute to the assembly of larger molecular cloud structures upon entering the spiral arm. The variation of molecular gas fraction within and between spiral arms can further constrain the time scale of molecular gas. In the plane of the Galaxy, spiral arm streaming motions may be evident as absorption features against a continuum source (protostars in a spiral arm) at velocities forbidden by Galactic rotation.

Wide field spectroscopic imaging of CII emission (R>300,000) from diffuse clouds at high Galactic latitudes that avoids the confusion of the Galactic plane can evaluate the role of converging flows in the formation of molecular clouds. Such flows may be revealed by large-scale velocity gradients centered on peaks of CO emission

(iii) Uniqueness to 10μm to few mm wavelength facility:

High-resolution spectroscopy is essential to identify gas motions in the environments of developing molecular clouds, which are sites of enhanced extinction. This precludes the application of UV/optical measurements. The atomic fine structure lines are the major coolants in the neutral atomic medium, and in addition to being readily observable, are the best probe of the transitions between atomic and molecular gas phases in the ISM.

(iv) Longevity/Durability (with respect to expected 2015-2030 facilities):

The mid- and far-IR lines can only be observed from airborne or space-based facilities so observations of these critical lines are currently limited to SOFIA. Programs as proposed here are not feasible with SOFIA given the target sensitivity and area coverage. Millimeter-wave interferometers (ALMA and NOEMA) and large single dish telescopes (LMT, IRAM 30m, NRO 45m) will provide the measurements that resolve CO emitting molecular clouds in nearby galaxies and the JVLA will continue to image the HI 21cm line with high angular resolution.

4. Table:

Parameter	Required value	Desired Value	Comments
Wavelength/band	17-205 μm	17-205 μm	H_2 to NII
Number of targets	10	>100	Select from LVL survey
Survey area	4-25 $arcmin^2$ 900 $arcmin^2$	4-25 $arcmin^2$ 3600 $arcmin^2$	per galaxy; depends on size; Milky Way clouds
Angular resolution	5" @158 μm	2" @158 μm	Resolve spiral arm segments and arm/interarm regions at 10 Mpc
Spectral resolution	R=100,000	R=500,000	Resolve streaming motions > 10 km/s and resolve Galactic components
Sensitivity	$2x10^{-9}$ $W/m^2/sr$ $\sigma(T_{mb})$=0.05 K	$4x10^{-10}$ $W/m^2/sr$ $\sigma(T_{mb})$=0.01 K	in 5 km/s wide channels @158 μm

5. Key references, (Optional, at most three, reviews preferred):

Dobbs, C.L., Krumholz, M., Ballesteros-Paredes, J., Bolatto, A., Fukui, Y., Heyer, M., Mac Low, M., Ostriker, E., Vazquez-Semadeni, E. 2014, in *Protostars and Planets VI*, Arizona Press, eds. Beuther, H., Klessen, R.S.,Dullemond, C.P., Henning, R. p. 3