IN-SYNC: Infrared Spectroscopy of Young Nebulous Clusters


¹University of Florida, ²Lowell Observatory, ³Yale University, ⁴ETH Zürich

ABSTRACT: IN-SYNC is an SDSS III APOGEE ancillary science project to measure stellar kinematics and binarity in star-forming regions to test theories of star and star cluster formation (Fig. 1). Our targets are shown in Fig. 2. (1) NGC 1333, a ~1 Myr old, heavily embedded cluster in the Perseus molecular cloud; (2) IC 348, a ~3 Myr old, optically revealed cluster, also associated with the Perseus cloud; (3) NGC 2264 (only partial coverage), also a ~3 Myr old cluster, which will be used specifically to assess the binary properties of pre-main sequence (PMS) stars. We anticipate that a typical 3 hour APOGEE visit achieves a 1 radial velocity (RV) precision of ~150 m/s for H<12.5 magnitude stars, with up to 200 stars measured simultaneously per observation. Due to stellar crowding in NGC 1333 and IC 348, several observing plates are needed to allow us to achieve our goal of ~75% completeness of the Hc=12.5 mag stars in these clusters (see Fig. 3). Our observations began in Aug. 2012; over the past ~6 months we have obtained as many as 9 observations for these targets in IC 348 and NGC 2264, providing good temporal coverage to check for possible RV variations due to binarity. This information will be used to help make statistical corrections for contamination of cluster velocity dispersion measurements in NGC 1333 and IC 348 due to binarity. Figure 4 shows some preliminary results for NGC 1333, comparing stellar motions with those of molecular gas.

THEORETICAL BACKGROUND: Measurement of the stellar kinematics of forming star clusters allows us to test theories of their formation. A number of fundamental questions are still debated, including "what is the timescale of the process?" and "what sets the star formation efficiency?" Tan et al. (2006) proposed formation times are relatively long compared to the local free-fall time. In this case, the system of stars and gas has time to approach approximate virial equilibrium, with implications for the observed stellar kinematics. Additionally, there is more time for dynamical evolution to lead to mass segregation of the stars, as well as merging and dissolution of sub-clusters. On the other hand, Elmegreen and Hartmann et al. (2012) have argued cluster formation takes just one or a few free-fall times. On the larger giant molecular cloud scale, different mechanisms may be responsible for triggering star cluster formation (e.g. cloud collisions, stellar feedback, spontaneous gravitational instability), which will have distinct kinematic signatures, i.e. of stellar motions compared to that of the surrounding gas (Fig. 3).