Revealing the Chamaeleon:

Young, low-mass stars surrounding η and ϵ Chamaeleontis

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Notes on the Digital Copy

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Several of the large catalogues used in this work have been tagged with their Virtual Observatory unique identifier (e.g. ivo://astronet.ru/cas/twomass-psc). As various data centres can have different versions and implementations of the same catalogue, this ensures any analysis is repeatable by denoting the exact catalogue *and* service that was used to obtain the data. Clicking on their identifiers will resolve the service descriptions in the directory hosted by the US Virtual Observatory (http://ww.us-vo.org).

Disclaimer

I hereby declare that the work in this thesis is that of the candidate alone, except where indicated below or in the text of the thesis. The work was undertaken between March 2007 and November 2011 at the Australian National University, Canberra. It has not been submitted in whole or in part for any other degree at this or any other university.

Chapter 2 is an expanded and updated version of the paper *'First detection of a low-mass stellar halo around the young open cluster η Chamaeleontis'*. Murphy, S. J., Lawson, W. A. & Bessell, M. S. 2010, MNRAS, 406, L50.

Chapter 3 is an expanded and updated version of the paper *'Episodic disc accretion in the halo of the 'old' pre-main-sequence cluster η Chamaeleontis'*. Murphy, S. J., Lawson, W. A., Bessell, M. S. & Bayliss, D. D. R. 2011, MNRAS, 411, L51.

Daniel Bayliss (RSAA/ANU) observed and reduced the *Magellan*/MIKE spectrum of 2MASS J0820−8003 which appears in the second paper and Chapter 3.

The balance of the observations, data reduction and analysis presented in these papers and chapters was performed solely by the candidate, who also wrote the text in its entirety. The co-authors provided valuable discussions and comments on the text.

The thesis was unconditionally accepted by a panel of expert examiners and ratified by the Dean of the College of Science on 23 January 2012. Following the suggestions of the examiners, this copy contains several improvements, additions and minor corrections.

Simon J. Murphy

16th February 2012

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Abstract

The deep southern sky surrounding the Chamaeleon dark clouds is abundant with pre–main sequence stars of various ages. Because of their youth (5–10 Myr) and proximity ($d \sim 100$ pc), members of two such stellar populations—the open cluster η Chamaeleontis and the nearby ϵ Chamaeleontis Association—are ideal laboratories in which to study the formation and evolution of sparse stellar groups and proto-planetary systems. To better understand their role as some of the closest evidence of recent star formation, this thesis explores the birth, dynamical evolution, accretion and disk properties of both groups' low-mass members.

The notable lack of low-mass stars in the young open cluster η Cha has long been a puzzle. Two possible explanations have been suggested; a top-heavy initial mass function or dynamical evolution, which preferentially ejected the low-mass members. Previous efforts to find these stars several degrees from the cluster core have been unsuccessful. By undertaking a wider (95 deg^2) photometric and proper motion survey with extensive follow-up spectroscopy, we have identified eight low-mass stars that were ejected from η Cha over the past 5–10 Myr. Comparison with recent N-body simulations shows our results are consistent with a dynamical origin for the current configuration of the cluster, without the need to invoke an initial mass function deficient in low mass stars.

Two of the dispersed members exhibited strong, variable Hα emission during our observations, including a star which had an event suggestive of accretion from a circumstellar disk. New infrared photometry confirms the presence of the disk. This star demonstrates that infrequent, episodic accretion can continue at low levels long after most disks around 'old' pre–main sequence stars have dissipated. Furthermore, we show that dynamical evolution is likely to be responsible for the higher-than-expected disk fraction observed in η Cha.

Another two non-members are slightly older than the cluster, but are only 42 arcseconds apart and share similar kinematics and distances. We have shown that they almost certainly form a wide (4000–6000 AU) ~10 Myr-old binary at 100–150 pc. The system is one of the widest pre–main sequence binaries known. Its isolation and dynamical fragility put strong constraints on any birthplace and mode of formation, which we propose was in a turbulent gas filament in the vicinity of the Scorpius-Centaurus OB Association.

In addition to η Cha, we have also examined membership of the unbound ϵ Chamaeleontis Association, which lies some 10 degrees to the east and has similar age, distance and kinematics. The two groups were almost certainly born in the outer regions of Sco-Cen only a few million years apart. Many members of ϵ Cha have been proposed in the decade since its discovery. After considering the kinematics of candidates from the literature, we have confirmed 11 further stars as likely members. Many of the new members possess infrared spectral energy distributions attributable to circumstellar disks, including four stars with strong Hα and forbidden emission which are actively accreting material.

This work on η and ϵ Chamaeleontis has identified many interesting targets for follow-up studies of disk evolution, accretion, binarity, and other investigations that require samples of nearby, intermediate-age pre–main sequence stars. Several avenues for future work are discussed in the last chapter of the thesis, including the impact of photometry and astrometry from the forthcoming SkyMapper Southern Sky Survey.

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