Publication of a Journal Paper

- Original research results

Publish or perish.

- Nature of the paper? Targeted readership?
- Targeted journal?
  - *Astrophysical Journal (ApJ)*
  - *Astronomical Journal (AJ)*
  - *Astronomy & Astrophysics (A&A)*
  - *Monthly Notices of the Royal Astronomical Society (MNRAS)*
  - *Icarus*
  - *Publication of the Astronomical Society of the Pacific (PASP)*
  - *PASJ, PASA, RAA…*

Plagiarism: using some one's ideas or data/information without proper referencing/citation or acknowledgment

It is unethical and often unlawful.

"Go ahead. Don't think of it as plagiarism, think of it as an homage."

https://www.facebook.com/retractionwatch/

Sketch a Writing Plan

- (A rough title, clear contents)
- Figures first *(what is the story?)*
- Section headings, subsections …
- Then each paragraph (a key word), and each sentence
- One concept/issue per paragraph
- Overall structure of the article

  Introduction, Observations/Data Analysis, Results/Discussions, Conclusions
- Then tackling a sentence at a time

  Simple (dull) sentences OK; get the "facts/results" in as placeholders

Evolution of a manuscript
– An example

- the draft
- a revised version
- the final submitted version

Publication of a Journal Paper

- Typesetting the manuscript
  - LaTex vs Word or other word processors overleaf
  - Text, figures, and tables
- Peer review by referee(s)
- Preprint and astro-ph (astrophysics – arXiv)
- Galley proof
- … in preparation; in submission; in press
  … private communications

A sample Latex file

```
\documentclass[12pt,preprint]{aastex}

\usepackage{graphicx}                    \usepackage{natbib}

\slugcomment{To be submitted to AJ; today is \today}

\begin{document}

\title{Typesetting by Latex for Graduate Seminar Course }
\author{ W. P. Chen\altaffilmark{1}   }

\altaffiltext{1}{Institute of Astronomy, National Central University, Jhongli 32001, Taiwan}
%
\begin{abstract}
%
 This is a sample                          Latex file, to see how professional typesetting is done.
 %
 \end{abstract}

 \section{Introduction}

 So this is how it works.

  The original file includes some ``commands'', but the contents are in ASCII.  Latex is
   particularly convenient to effectively produce Greek letters, $\alpha, \beta, \Omega$, and
    math $\int_0^{100} \sin\omega d\omega$.

 \end{document}
```

Output of the LaTex file

To be submitted to AJ; today is March 9, 2011

Typesetting by Latex for Graduate Seminar Course

W. P. Chen[1]

ABSTRACT

This is a sample Latex file, to see how professional typesetting is done.

1. Introduction

So this is how it works.

The original file includes some "commands", but the contents are in ASCII. Latex is particularly convenient to effectively produce Greek letters, α, β, Ω, and math $\int_0^{100} \sin \omega d\omega$.

---

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Serendipitous Discovery of Brown Dwarfs using the LAMOST Spectra

overleaf.com/project/5bb5a4c367b04d11c24c42b4

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Source | Rich Text | Recompile

aasjournal.bst
aastex62.cls
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CPM_image.pdf
CPM_image_2019_07_14...
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```
%\documentclass[manuscript]{aastex62}
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\newcommand{\sy}[1]{\textcolor{cyan}{SY:#1}}
%-------------------------------------------------------------------------------------------------------%
\shorttitle{LAMOST Brown Dwarfs}
\shortauthors{Wang et al.}
%-------------------------------------------------------------------------------------------------------%
%-------------------------------------------------------------------------------------------------------%
\begin{document}

\title{Spectroscopically Identified Late-M Dwarfs and Brown Dwarfs by LAMOST}
%DR6: late type M and early L dwarfs



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```

DRAFT VERSION MARCH 19, 2020
Typeset using LaTeX **modern** style in AASTeX62

Spectroscopically Identified Late-M Dwarfs and Brown Dwarfs by LAMOST

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ABSTRACT

We present a list of 295 dwarfs with spectral types later than late-M types on the basis of the LAMOST spectra. This sample, after human inspection to exclude possible giant star contamination, consists mainly of field brown dwarfs, and includes one L0 object and 20 comoving pairs. ?? therefore contributes to enlarge the spectroscopically confirmed brown dwarf (BD) population in the solar neighborhood. (more on the pairs)

Keywords: surveys—stars: late-type—stars: low-mass—brown dwarfs—binaries: visual

1. INTRODUCTION

Brown dwarfs (BDs) are objects not massive enough to sustain core hydrogen fusion, i.e., they are substellar having masses $M \lesssim 75$–$80\ M_J$, where M_J is the Jupiter mass. Theories indicate that those more massive than $\sim 65 M_J$ have cores hot enough to fuse lithium, and those above $\sim 13 M_J$ may ignite deuterium. Other than these short-lasting fusion reactions, a BD continues to cool and fades monotonically in

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下午 02:36
2020/3/19

Sustaining Star Formation in the Galactic Star Cluster M 36

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ABSTRACT

We report the study of the star formation scenario in the Galactic open cluster M 36, which occurred more than 20 Myrs ago forming the star cluster, and is still ongoing in the last 1–2 Myr in the molecular cloud to the south-west of the cluster. A total of some two hundreds member candidates have been identified on the basis of proper motion and parallax diagnosis by the *Gaia* DR2. Using the same set of selection criteria on a nearby control field, a false positive rate of 9.6% is expected. The cluster has a distinct *Gaia* DR2 proper motion grouping around (μ_α $cos\delta = -0.15 \pm 0.01$ mas yr^{-1}, $\mu_\delta = -3.35 \pm 0.02$ mas yr^{-1}), which is clearly separated from the field motion. The *Gaia* DR2 parallax measurements of member candidates suggest a cluster distance of 1.1 to 1.4 kpc with a median range of 1.20 ± 0.13 kpc. The angular size of $13\rlap{.}'5 \pm 0\rlap{.}'4$ determined from the radial density profile then corresponds to a linear extent of 4.71 ± 0.14 pc. The K-band extinction map suggests the existence of a very high extinction complex ($A_V \sim 23$ mag) for a compact region ($\sim 1\rlap{.}'9 \times 1\rlap{.}'2$) with an average value of $A_V \simeq 3.8 \pm 0.7$ mag. A total of four young stellar objects (YSOs) are identified from the infrared color excess and three of them are associated with the high extinction complex. The YSOs are in very early stage of their evolution (age < 0.2 Myr) as predicted from the spectral energy distributions. The radial velocity of the members is estimated as ~ -21 km s^{-1}, using the velocity distributions of the emission peaks of ^{12}CO and ^{13}CO radio data. The cospatial distribution of the YSOs and the enhanced molecular cloud structures infer recent star formation activity within the cluster.

Keywords: open clusters and associations: individual (M 36) - stars: kinematics and dynamics - open clusters and associations: formation - stars: pre-main sequence

1. INTRODUCTION

Most and perhaps all stars are formed in a clustered environment out of molecular clouds. Those that survive the internal dynamic ejection and external disruption are now seen as star clusters (Lada & Lada 2003). Open clusters preserve, and hence serve as probes to trace, the history of the formation, dynamical and chemical evolution of the Galactic disk(s). Studies of open clusters furnish wealth of information about large-scale properties of the Galactic disk population (Piskunov et al. 2006). Being formed in a same molecular cloud, members of a star cluster share similar chemical composition, and have roughly the same age, distance, and space motion (Lin, Chen & Panwar 2013; Wang et al. 2014; Tang et al. 2018). Whereas spatial structure represents the distribution of sibling stars within a cluster according to their mass or brightness.

The present day cluster properties can be used to estimate the past history of the stellar evolution. The structure of a cluster is highly dependent on the initial physical conditions of the parental molecular cloud, initial structure, and external field perturbation (Chen et al. 2004; Sharma et al. 2008). Depending on the initial physical factors and the stellar feedback, a cluster may exhibit varying levels of star formation activity during its evolution. In the early stages of star formation, stars are physically associated with significant amounts of interstellar dust and gas, where the infrared and radio wavelength surveys can provide much of the insights (Myers et al. 1987; Wilking, Lada & Young 1989; Lada &

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and radio wavelength surveys can provide much of the insights (Myers et al. 1987; Wilking, Lada & Young 1989; Lada & Adams 1992; Churchwell et al. 2006; Samal et al. 2015; Li et al. 2018, 2019).

M 36 (also NGC 1960), located at $\alpha_{2000} = 05^h36^m18^s$, $\delta_{2000} = +34°08'24''$, is a rich star cluster near the center of the Aur OB1 association. The cluster spans an angular diameter of 10′ according to the Lyngå (1987) catalogue. Morphologically the cluster is dominated by about 15 bright ($V \lesssim 11$ mag) stars. Barkhatova et al. (1985) estimated a reddening $E(B-V) = 0.24$ mag, and distance of 1200 pc to the cluster, and an age of 30 Myr from the main-sequence turn-off. Using the proper motion data (down to $V = 14$) and BV CCD photometry ($V = 19$), Sanner et al. (2000) presented $E(B-V) = 0.25 \pm 0.02$ mag, distance $= 1318 \pm 120$ pc, and age $= 16^{+10}_{-5}$ Myr from isochrone fitting and metallicity Z = 0.02 for the cluster. Sharma et al. (2006) determined the core radius of the cluster as 3′.2 (1.2 pc) and the cluster is extended up to 14′ (5.4 pc) from projected radial density profile of the main-sequence stars down to $V \leq 18$ mag. From the optical and infrared color-color (CC) and color-magnitude (CM) diagram analysis, they calculated log (age) = 7.4 (25 Myr) and distance ≈ 1330 pc, considering reddening $E(B-V) = 0.22$ mag to the stellar distribution. Using Johnson & Morgan (1953) photometry and a sophisticated fitting technique Mayne & Naylor (2008) reported $E(B-V) = 0.20 \pm 0.02$ mag, distance $= 1174^{+61}_{-42}$ pc, and Age ∼ 20 Myr. Based on a robust statistical fitting approach Bell et al. (2013) adopted the cluster age 20 Myr, distance modulus $= 10.33^{+0.02}_{-0.05}$ mag (d $= 1164^{+11}_{-26}$ pc), and $E(B-V) = 0.20$ mag. By adopting lithium depletion boundary technique, Jeffries et al. (2013) determined the cluster age of 22 ± 4 Myr, from a sample of very low-mass cluster candidates.

In this paper, we present a detailed survey of identifying the cluster members and explore their interplay with the associated molecular clouds and ongoing star formation activity toward M 36. In Section 2, we describe the several data sets utilized, the reduction processes, their quality, and the limitations. The results are presented in Section 3. The cluster parametrization and selection of the members are discussed here. Mapping the distribution of extinction, identifying and characterizing the young stars and the radial velocity are analysed in Section 4. The sustaining star formation within the cluster is discussed in Section 5. The crucial results are summarized in Section 6.

are those foreground or background stars in the direction of the cluster, that have different origin evolutionary phase or kinematic motion. Hence, the membership analysis of stars in a cluster region has become an intense subject of interest to understand the cluster properties and its evolution.

The identification of members within the cluster region relied on grouping of stars in spatial distribution, proper motion distribution, and measurements of parallax. We used the UKIDSS, 2MASS, and *Gaia* DR2 catalogs to estimate those parameters.

3.1. *Radial Density Profile*

M 36 has been known to have an elongated shape, with the aspect ratio of 0.2–0.3, tilted some 20° away from the plane (Chen et al. 2004; Kharchenko et al. 2009). Using King profiles, Piskunov et al. (2007) estimated an empirical angular radius 16′.2, and a total mass ∼ 200 M$_\odot$ within the tidal radius 9 pc.

In order to determine the M 36 cluster extension, we utilized the UKIDSS K-band photometry. The central coordinates ($\alpha_{2000} = 05^h36^m18^s$, $\delta_{2000} = +34^d08^m24^s$) as informed in the SIMBAD database[7] are adopted to construct the radial density profile (RDP) and analyse the stellar density distribution with respect to the background. The RDP is generated by counting the number of stars inside each concentric circular rings of widths 1.5 arcmin, upto a radius of 35 arcmin, and dividing this number by the respective ring area. The radial density distribution of the stars toward the M 36 cluster is shown in the Fig. 1. The peak radial density is obtained as ∼ 26.4 ± 2.5 stars arcmin^{-2}. The mean background stellar density is ∼ 14.8 ± 0.3 stars arcmin^{-2} and is shown by the horizontal dashed line. The Fig. 1 shows that the density profile starts to blend with the field population at radius ∼ 13′.5. Therefore we adopted the cluster radius as 13′.5 ± 0′.4 (4.71 ± 0.14 pc) as one of the membership parameter and is depicted by the green dashed vertical line in Fig. 1. Our estimation of the cluster radius is almost consistent with the earlier work of Sharma et al. (2006), determined as 14′ using the optical photometry. The primary minima at radius 6′ (2.1 pc), indicated by red dashed vertical line, infers the possible end of molecular cloud association (Section 5.1).

[7] http://simbad.u-strasbg.fr/simbad/sim-fid

Reference Styles   Last (family) name, (middle), first name (initials)

Nature

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2. Mumma, M. I., Weissman, P. R. & Stern, S. A. in *Protostars and Planets III* (eds Levy, E. H., Lunine, J. I. & Matthews, M. S.) 1177–1252 (Univ. Arizona Press, Tucson, 1993).
3. Whipple, F. L. A comet model I: The acceleration of comet Encke. *Astrophys. J.* **111,** 375–394 (1950).

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Conti, P. S., Garmany, C. D, deLoore, C., & Vanbeveren, D. 1983, ApJ, 274, 302

Annual Review of Astronomy and Astrophysics

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Class Exercise --- A sample letter

Dear Takahashi-san

I am so concern about the devastations triggering by terrible earthquake and tsunami in Japan. Everyday, I read news and pray for the things will going well many times.
GAO is quite close to the Toyko. Are people and every things in GAO allright?

God Bless you and eveyone in GAO

- What does this letter try to say?
- What are the problems with it?

Let us try to improve it.

V-ed … passive, to me

We are interested in the event. I am bored.

V-ing … active, to others

The movie is interesting. I am boring (!)

A referee report …

Mind the Pronunciation

Read out loud and listen (to yourself)

- mor<u>pho</u>logy ***vs*** morpho<u>lo</u>gical
- <u>mo</u>lecule ***vs*** mo<u>le</u>cular
- a<u>na</u>lysis ***vs*** <u>an</u>alyze/analyse
- s<u>pe</u>ctra ***vs*** spec<u>tro</u>scopy ***vs*** spectros<u>co</u>pic
- Mag<u>ne</u>tic ***vs*** <u>ma</u>gnetism

Mind the Sentence Structure/Grammar

- We would like to find out what the dark energy is.
  You may wonder “What is the dark energy?”
- The value of using multiple databases *is* consistency.

Mind the Uses/Meaning of Words

- I look forward to it. Looking forward to seeing you.
- I do not know what you mean.
- I used to go to school in Taipei.
- I am used to it.
- I have little money.

✓The light went out, because the power was out. (*direct reasoning/causality*)

The power must be out, for the light went out. (*conjecture, inference*)
It is morning, because the birds are singing. (X)

✓Since you are here, you may as well stay. (*nature result; 既然*)

✓As I was not sure, I changed the text.

Exercise

Select a personal "model" paper. In one paragraph, describe its main contents. In another paragraph, explain why it is your model paper. List the headings, and subheadings if any, of the paper. Paraphrase in your own words its first two paragraphs in the "Introduction" section.

My Model paper …

A SURVEY FOR CIRCUMSTELLAR DISKS AROUND YOUNG STELLAR OBJECTS

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Department of Astronomy, Space Science Building, Cornell University, Ithaca, New York 14853

ANNEILA I. SARGENT
Department of Physics, Mathematics and Astronomy, California Institute of Technology, Pasadena, California 91125

ROLF. S. CHINI AND ROLF GÜSTEN
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Received 6 July 1989; revised 3 November 1989

ABSTRACT

Continuum observations at 1.3 mm of 86 pre-main-sequence stars in the Taurus–Auriga dark clouds show that 42% have detectable emission from small particles. The detected fraction is only slightly smaller for the weak-line and "naked" T Tauri stars than for classical T Tauris, indicating that the former stars often have circumstellar material. In both categories, the column densities of particles are too large to be compatible with spherical distributions of circumstellar matter—the optical extinctions would be too large; the particles are almost certainly in spatially thin, circumstellar disks. Models of the spectral energy distributions from 10 to 1300 μm indicate that for the most part the disks are transparent at 1.3 mm, although the innermost ($\leqslant$1 AU) regions are opaque even at millimeter wavelengths. The aggregate particle masses are between 10^{-5} and 10^{-2} $\mathscr{M}_\odot$, implying total disk masses between 0.001 and 1 $\mathscr{M}_\odot$. The disk mass does not decrease with increasing stellar age up to at least 10^7 years among the stars detected at 1.3 mm. There is some evidence for temperature evolution, in the sense that older disks are colder and less luminous. There is little correlation between disk mass and Hα equivalent width among the detected stars, suggesting that the Hα line is not by itself indicative of disk mass. Spectral indices for several sources between 1.3 and 2.7 mm suggest that the particle emissivities ϵ are weaker functions of frequency ν than is the usual case of interstellar grains. Particle growth via adhesion in the dense disks might explain this result. The typical disk has an angular momentum comparable to that generally accepted for the early solar nebula, but very little stored energy, almost five orders of magnitude smaller than that of the central star. Our results demonstrate that disks more massive than the minimum mass of the proto-solar system commonly accompany the birth of solar-mass stars and suggest that planetary systems are common in the Galaxy.

I. INTRODUCTION

There is little doubt that the solar system was born from a disk of gas and dust encircling the Sun five billion years ago. The evidence that similar disks surround many young, solar-mass stars in the Galaxy today is compelling, although it is usually circumstantial. Basic quantities such as the disk mass are poorly constrained by available observations, however, making it impossible to ascertain the number of stars that will eventually have planetary systems like our own. If the distribution of mass and energy, the characteristics principally responsible for disk evolution, were known, we could begin to assess whether planetary systems are common or rare and, by comparing planetary evolution around neighboring stars, gain insight into our origins.

Most estimates suggest that approximately half of all young stars have disks. Strom *et al.* (1989; hereafter referred to as SSECS) use the presence of infrared emission in excess of that expected from a stellar photosphere to infer the presence of disks around 60% of the youngest pre-main-sequence stars in their sample. In a similar study, Cohen, Emerson, and Beichman (1989) examined 72 stars in Taurus–Auriga and concluded that about one-third of the stars have appreciable disks. Calculations of emission from circumstellar disks [Lynden-Bell and Pringle 1974; Adams, Lada, and Shu 1987 (hereafter referred to as ALS), 1988; Kenyon and Hartmann 1987; Bertout, Basri, and Bouvier 1988] demonstrate clear infrared signatures accompanying disks similar to the proto-solar nebula; these calculations provide the underpinnings for the observations cited above, but are not the only indicators of disk matter. The disks indirectly affect other radiation, for example, by shadowing the receding portions of stellar mass loss and creating preferentially blueshifted spectral lines (Edwards *et al.* 1987), asymmetric scattering of visual and near-infrared light from the stars (Beckwith *et al.* 1989), anomalously large extinction (Cohen 1983), and large degrees of polarization of the starlight (Bastien 1982; Hodapp 1984; Sato *et al.* 1985). But these effects are less useful for understanding the frequency with which disks occur.

At wavelengths shortward of 100 μm, these disks are usually opaque, making infrared and visual observations insensitive to the mass of the disks. The strengths of the far-infrared emission depends on the disks luminosity and temperature distribution, both strong functions of the energy balance in the disk (cf. Sec. IV*c*). To discuss the likelihood of planet formation, it is desirable to measure the total mass in a disk and its spatial distribution.

Thermal emission from small particles entrained in these disks is optically thin at wavelengths of order 1 mm and is proportional to the total particle mass (Beckwith *et al.* 1986; Sargent and Beckwith 1987). Observations of millimeter-wave emission from young stars provide an excellent way to measure disk masses directly, minimizing the uncertainties introduced by energetic activity near the star. With the unprecedented sensitivity and spatial resolution of the new

Model Paper

W. P. Chen

April 2020

My model paper is Beckwith, Sargent, Güsten (1990, AJ, 99, 924), in which they reported a survey of emission at 1.3 mm of 86 pre-main-sequence (PMS) stars, including classical T Tauri stars, and weak-line T Tauri stars, in the Taurus star-forming clouds.

I chose this paper because (1) I am interested in ths subject, (2) it was among the first comprehensive studies of the dust contents of PMS disks with millimeter instruments, and (3) the assumptions and derivation of formulae are lucidly presented.

The first paragraph introduces the circumstellar disks of new born stars, which are known to exist but lack quantitative characterization. The statistics of the disks, and also their mass and energy would shed light on planet formation.

The second paragraph summarizes the relevant literature on the fraction (about 1/2) of young stars with disks, usually on the basis of IR excess, by occultation by disks, etc. This will lead to direct measurements described in the next paragraph.

Your model paper is not just a paper, or the only one you have read; it should be the one that you hope to write like that some day.

- ✓ "*There is always a better way*."
- ✓ Always strive to do your best, even though currently <u>your best may not be good enough</u>.

A recent one 2021.08.21 for a Maidanak Users Meeting

I am glad the dates have been extended, as I missed the August 1 deadline. I just tried to register but was dismayed of the choice of country as "a province of China". I am not trying to solve the grandiose political issue, but this is simply confusing, and could be solved with replacing with a different template pull-down table.

Please consider. Thank you.

Wen Ping

Dear Mr. Wen Ping,

The changes are made and you can proceed with the registration.

Please let us know if you need any assistance from our side.

Best regards,
Barno

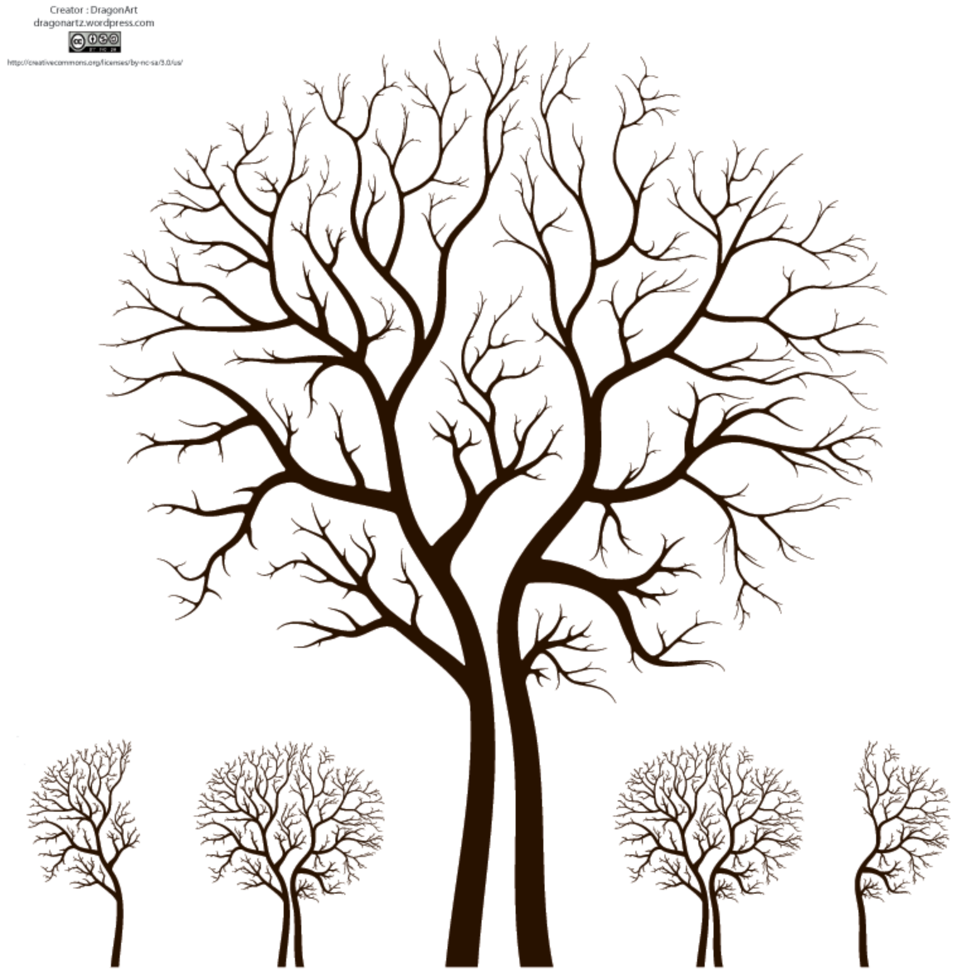
2021.08.21

Anthropomorphism （擬人）

- Experiments/data do not prove or explain; figures/tables do not compare. They “show” or “indicate”.
- (X) *This experiment attempts to demonstrate that …*
  (O) *The purpose of this experiment is to demonstrate that …*
- (X) *The research found that …*
  (O) *The researchers found that …*
- (X) *Their paper discussed the possible relation of …*
  (O) *Lin et al. (2013) discussed the possible relation of …*

Paper Structure --- the skeleton

- Title = face
- Abstract = heart
- Key Words = address
- Headings = skeleton
- Introduction = hands
- Data and Analysis
- Discussion (visuals) = voice
- Conclusion = smile
- References



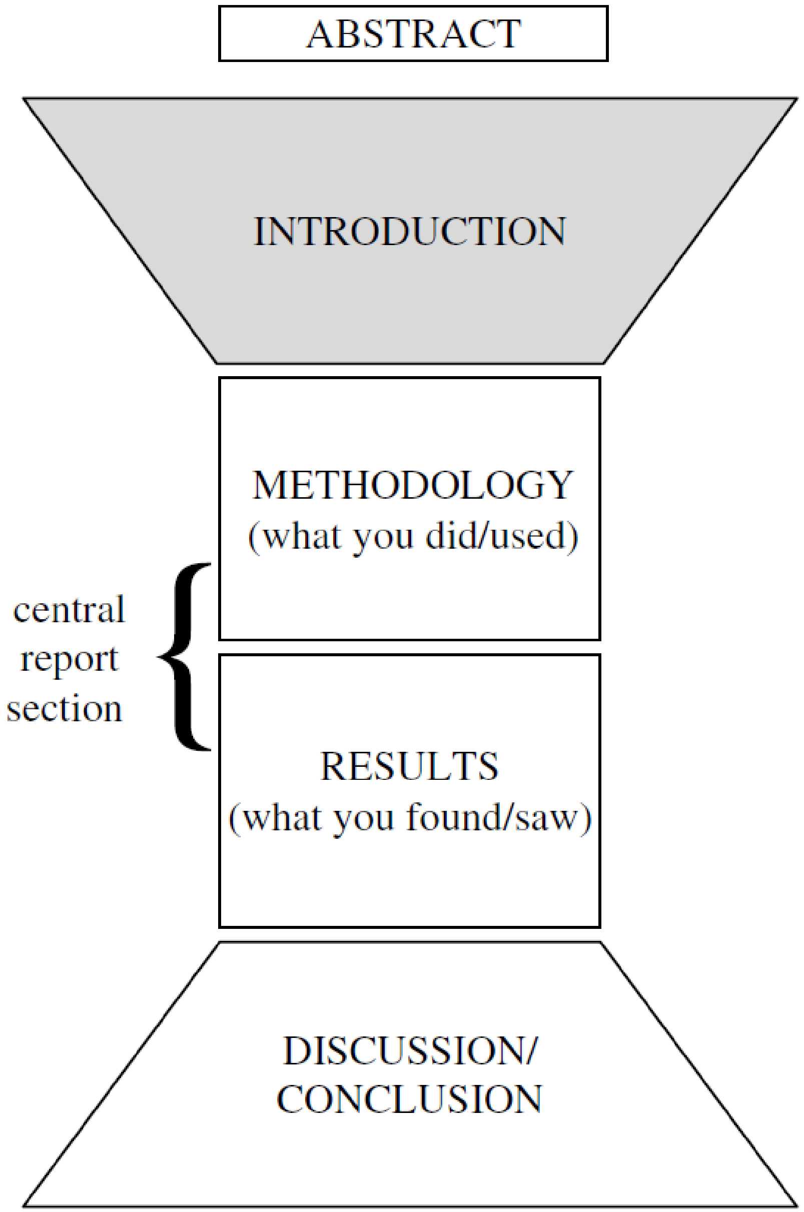


Fig. 1. The shape of a research article or thesis.

First impression

Today, as the city's bowels demonstrate their usual constipation, the pouring rain adds a somewhat slimy aspect to the slow procession of traffic. Professor Leontief does not like arriving late at the lab. He hangs his dripping umbrella over the edge of his desk, at its designated spot above the trashcan, and he gently awakens his sleepy computer with some soothing words: "Come on, you hunk of metal and silicon oxide, wake up."

He checks his electronic mail. The third e-mail is from a scientific journal which he helps out as a reviewer. "Dear Professor Leontief, last month you kindly accepted to review the …." He need not read any further. He looks at his calendar, and then feels the cold chill of panic run up his spine when he realises that the deadline is only 2 days away. He hasn't even started. So much to do with so little time! Yet, he cannot postpone his response. Being a resourceful man, he makes a couple of telephone calls and reorganises his work schedule so as to free up an immediately available 2-hour slot.

He pours himself a large mug of coffee, and extracts the article from the pile of documents pending attention. He goes straight to the reference section on the last page to check if his own articles are mentioned. He grins with pleasure. As he counts the pages, he looks at the text density. It shouldn't take too long. He smiles again. He then returns to the first page to read the abstract. Once read, he flips the pages forward slowly, taking the time to analyse a few visuals, and then moves to the conclusions, reading them with great care.

(*Continued*)

(*Continued*)

He stretches his shoulders and takes a glance at his watch. Twenty minutes have gone by since he started reading. By now, he has built a first and strong impression. Even though the article is of moderate length, it is too long for the depth of the proposed contribution. A letter would have been a more appropriate format than a full-fledged paper. Poor researcher. He will have to say this, using diplomatic skills so as not to be discouraging, for he knows the hopes and expectations that all writers share. What a shame, he thinks. Had he accepted the paper, his citation count would have increased. Now the hard work of thorough analysis lies ahead. He picks up his coffee mug and takes a large gulp.

The first impression of a paper is formed after a partial reading. During the first 20 minutes or so, a reviewer does not have time to read the whole paper, in particular the methodology and the results/discussion sections. I have therefore decided to cover in part II only those parts of a paper that are read during the rapid time in which the first impression is formed. This decision was also based on comments from scientists who have published many papers. They stated that the methodology and results sections of their paper were the easiest and fastest to write, but it was the other parts that were difficult and took time: the abstract, introduction, and conclusions. As for the title, structure, and visuals, they recognised that they had underestimated the key role these parts play in creating the first impression.

The impact of the quality of these parts goes beyond creating a favourable first impression for the reviewer and reader. Improved

Writing Plan (cont.)

(Placeholder)

- Title, possible coauthors (affiliations)

  Who should be included anyway?

- Abstract can wait
- Figures
- Section headings, subsections …

  Introduction, Observations/Data Analysis, Results/Discussions, Conclusions

- Then each paragraph (a concept or an issue; a key word)
- Expansion of each key word

  5-10 sentences? Combination to form more sophisticated sentences.

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Discovery of Tidal Tails in Disrupting Open Clusters: Coma Berenices and a Neighbor Stellar Group

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Abstract

We report the discovery of tidal structures around the intermediate-aged (∼700–800 Myr), nearby (∼85 pc) star cluster Coma Berenices. The spatial and kinematic grouping of stars is determined with the *Gaia* DR2 parallax and proper motion data, by a clustering analysis tool, StarGO, to map 5D parameters (X, Y, Z, $\mu_\alpha \cos\delta$, μ_δ) onto a 2D neural network. Leading and trailing tails, each with an extension of ∼50 pc are revealed for the first time around this disrupting star cluster. The cluster members, totaling $\sim 115^{+5}_{-3}\,M_\odot$, are clearly mass-segregated, and exhibit a flat mass function with $\alpha \sim 0.79 \pm 0.16$, in the sense of $dN/dm \propto m^{-\alpha}$, where N is the number of member stars and m is stellar mass, in the mass range of m = 0.25–2.51 $M_\odot$. Within the tidal radius of ∼6.9 pc, there are 77 member candidates with an average position, i.e., the cluster center, of R.A. = 186°.8110, and decl. = 25°.8112, and an average distance of 85.8 pc. Additional 120 member candidates reside in the tidal structures, i.e., outnumbering those in the cluster core. The expansion of escaping members lead to an anisotropy in the velocity field of the tidal tails. Our analysis also serendipitously uncovers an adjacent stellar group, part of which has been cataloged in the literature. We identify 218 member candidates, 10 times more than previously known. This star group is some 65 pc away from, and ∼400 Myr younger than, Coma Ber, but is already at the final stage of disruption.

Key words: open clusters and associations: individual (Coma Berenices) – stars: evolution – stars: kinematics and dynamics

Supporting material: machine-readable tables

1. Introduction

Stars are born in dense molecular clouds, and those that remain gravitationally bound appear as star clusters (Lada & Lada 2003). Stars inside a cluster interact with each other via two-body relaxation. As a consequence, massive members slow down and sink to the cluster center, where low-mass stars speed up, progressively occupying a larger column and eventually escaping. The so-called "mass segregation" is often observed in star clusters (Hillenbrand & Hartmann 1998; Pang et al. 2013; Tang et al. 2018). In the meantime, Galactic potential perturbs star clusters leading to the formation of tidal structures. For example, giant tidal tails have been found in the isolated halo globular cluster Palomar 5 (Odenkirchen et al. 2001, 2003).

The Galactic disk is abundant in stars, spiral arms, and giant molecular clouds. Therefore, star clusters located in the disk are subjected to disturbance, such as disk shock, spiral arm passage, molecular cloud encounters, etc. (Spitzer 1958; Kruijssen 2012). The typical survival timescale of open clusters in the Galactic disk is about 200 Myr (Bonatto et al. 2006; Yang et al. 2013). Open clusters much older than the survival timescale must have their shape distorted, and structure loosened, leading to inevitable disruption. The disintegrated open clusters become moving groups and then supply field stars. A small portion of these stellar group remnants can be identified by the convergent-point method (Boss 1908) in the solar neighborhood (such as the TW Hydrae association, AB doradus moving group, and more; Zuckerman & Song 2004).

However, detection of tidally disrupted substructures of open clusters is painstaking. The low number density of a tidal tail may cause its members to be buried in the dense foreground and background field stars. Accurate kinematic data are essential to recover such substructures. *Gaia* data revolutionize this study by providing high-precision proper motion (PM) and parallax (ϖ) for nearby open clusters (e.g., Cantat-Gaudin et al. 2018). Based on the 3D motions from the *Gaia* TGAS catalog, Oh et al. (2017) identified more than 4555 moving groups in the solar neighborhood. However, only 61 of them have more than 5 members, among them, 10 are related to known associations. The second data release (DR2) of *Gaia* (Gaia Collaboration et al. 2018) with a higher accuracy on kinematic data, makes it possible to directly reveal tidal tails, e.g., in the nearest open cluster, Hyades (Meingast & Alves 2019; Röser et al. 2019).

The open cluster Coma Berenices (Melotte 111, hereafter Coma Ber) with an age around 800 Myr (Tang et al. 2018) is the second nearest (86.7 pc; Tang et al. 2018) star cluster to the Sun. However, with a large sky coverage and an average PM with no significant difference from that of the field stars, Coma Ber has received less attention compared to other nearby clusters. The earliest studies on Coma Ber can be dated back to Melotte (1915) and Trumpler (1938). Later on, Odenkirchen et al. (1998) used the *Hipparcos* and *Tycho* plus the ACT Reference Catalog (Urban et al. 1998), to perform, for the first time, a detailed study with parallax information of Coma Ber, and found a core-halo structure with the major axis parallel to the direction of the Galactic orbital motion of the cluster. They also detected a group of stars with a tangential distance >10 pc from the cluster center, which they called the "moving group" of Coma Ber. By studying the luminosity function, they found more faint stars in the moving group than in the central cluster, and therefore concluded that Coma Ber was under the process of dissolution. A similar conclusion was given in the later studies by Casewell et al. (2006), Kraus & Hillenbrand (2007), and Tang et al. (2018).

Using the data from *Gaia* DR2, we explore the neighborhood of Coma Ber and search for tidal tail substructures. In Section 2, we introduce the quality and limitation of the *Gaia* DR2 data, and explain our input data set for structure identification. We then present the algorithm, StarGO, which is used to identify structures. The results are shown in Section 3. The dynamical status of Coma Ber and the nearby associated structures, Group-X is discussed in Section 4. Finally, we provide a brief summary in Section 5.

cluster formation and destruction

Stars are born in dense molecular clouds, and those that remain gravitationally bound appear as star clusters (Lada & Lada 2003). Stars inside a cluster interact with each other via two-body relaxation. As a consequence, massive members slow down and sink to the cluster center, where low-mass stars speed up, progressively occupying a larger column and eventually escaping. The so-called "mass segregation" is often observed in star clusters (Hillenbrand & Hartmann 1998; Pang et al. 2013; Tang et al. 2018). In the meantime, Galactic potential perturbs star clusters leading to the formation of tidal structures. For example, giant tidal tails have been found in the isolated halo globular cluster Palomar 5 (Odenkirchen et al. 2001, 2003).

destruction process and timescales

The Galactic disk is abundant in stars, spiral arms, and giant molecular clouds. Therefore, star clusters located in the disk are subjected to disturbance, such as disk shock, spiral arm passage, molecular cloud encounters, etc. (Spitzer 1958; Kruijssen 2012). The typical survival timescale of open clusters in the Galactic disk is about 200 Myr (Bonatto et al. 2006; Yang et al. 2013). Open clusters much older than the survival timescale must have their shape distorted, and structure loosened, leading to inevitable disruption. The disintegrated open clusters become moving groups and then supply field stars. A small portion of these stellar group remnants can be identified by the convergent-point method (Boss 1908) in the solar neighborhood (such as the TW Hydrae association, AB doradus moving group, and more; Zuckerman & Song 2004).

problems, difficulties & solutions

However, detection of tidally disrupted substructures of open clusters is painstaking. The low number density of a tidal tail may cause its members to be buried in the dense foreground and background field stars. Accurate kinematic data are essential to recover such substructures. *Gaia* data revolutionize this study by providing high-precision proper motion (PM) and parallax (ϖ) for nearby open clusters (e.g., Cantat-Gaudin et al. 2018). Based on the 3D motions from the *Gaia* TGAS catalog, Oh et al. (2017) identified more than 4555 moving groups in the solar neighborhood. However, only 61 of them have more than 5 members, among them, 10 are related to known associations. The second data release (DR2) of *Gaia* (Gaia Collaboration et al. 2018) with a higher accuracy on kinematic data, makes it possible to directly reveal tidal tails, e.g., in the nearest open cluster, Hyades (Meingast & Alves 2019; Röser et al. 2019).

Target background info, literature

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this work

Using the data from *Gaia* DR2, we explore the neighborhood of Coma Ber and search for tidal tail substructures. In Section 2, we introduce the quality and limitation of the *Gaia* DR2 data, and explain our input data set for structure identification. We then present the algorithm, STARGO, which is used to identify structures. The results are shown in Section 3. The dynamical status of Coma Ber and the nearby associated structures, Group-X is discussed in Section 4. Finally, we provide a brief summary in Section 5.

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Diagnosing the Stellar Population and Tidal Structure of the Blanco 1 Star Cluster

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Abstract

We present the stellar population, using *Gaia* DR2 parallax, kinematics, and photometry, of the young (∼100 Myr), nearby (∼230 pc) open cluster, Blanco 1. A total of 644 member candidates are identified via the unsupervised machine learning method STARGO to find the clustering in the five-dimensional position and proper motion parameter (X, Y, Z, $\mu_\alpha \cos\delta$, μ_δ) space. Within the tidal radius of 10.0 ± 0.3 pc, there are 488 member candidates, 3 times more than those outside. A leading tail and a trailing tail, each of 50–60 pc in the Galactic plane, are found for the first time for this cluster, with stars further from the cluster center streaming away faster, manifest stellar stripping. Blanco 1 has a total detected mass of $285 \pm 32\ M_\odot$ with a mass function consistent with a slope of $\alpha = 1.35 \pm 0.2$ in the sense of $dN/dm \propto m^{-\alpha}$, in the mass range of 0.25–2.51 $M_\odot$, where N is the number of members and m is stellar mass. A minimum spanning tree ($\Lambda_{\rm MSR}$) analysis shows the cluster to be moderately mass segregated among the most massive members ($\gtrsim 1.4\ M_\odot$), suggesting an early stage of dynamical disintegration.

Unified Astronomy Thesaurus concepts: Stellar evolution (1599); Stellar mass functions (1612); Open star clusters (1160)

Supporting material: machine-readable table

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