

The Challenges Ahead ...

Les Houches, France, August 1983



Hans

In Munich, 1996

Holding proceedings of the Henry Draper Symposium
on the Orion Nebula. Held in 1982, New York



Thinking great thoughts:

On the train from
Ringberg To Munich

1996



The Challenges Ahead ...



The audience is asked to break up in to small
~9 subgroups (with ~10 in each group)
for a few minutes to discuss,
and have their younger members give a short (~60 second)
summary of each subgroup's deliberations.

STRUCTURE AND KINEMATICS OF THE ISM:

- What is the primary driver of structure formation in the ISM?
Thermal instability? B? gravitational fragmentation? Feedback?
In-fall from outside galaxy? Other?
- What processes create turbulence? On What scales? Multi-scale injection?
- Where and how do C.R.s (especially Low Energy Cosmic Rays) form, propagate, and interact with the ISM?
- What is the role of atomic gas in SF?
- How does metallicity variation impact SF? HI=> H2 transition, and the heating & Cooling balance?
- Can OB stars accelerate SF and/or compress surviving CO clouds?
Does RDI or triggering work?

STARS: THE IMF, MASSIVE STARS, and CLUSTERS - I

- What sets the upper mass-limit for stars?
- Origins and variation of the IMF?
- How Universal is the IMF? What scales need to be sampled?
- Do O-stars ever form in isolation? How common or rare?
- Connecting small scales to the large (e.g. ALMA to large scale)
planets, stars, disks, clusters, bubbles, super bubbles, spiral arms?
- How do binaries form?
- What determines the SFR and SFE?
- What are the roles of magnetic fields?
- How important is B in limiting SFR
- How do stars (incl. massive stars) form in CMZs near galactic nuclei?
- What do eruptions (FU Ori, Sh2-255, NGC6334 I, ...) tell us?

STARS: THE IMF, MASSIVE STARS, and CLUSTERS - II

- What are the properties of massive-star disks?
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- How does high accretion rate work in MYSOs?
- What is the role of feedback? Which elements dominate? Where and when?
- Which feedback mechanisms halt SF and disrupt GMCs?
How does this depend on scales?
- Do massive stars have an observable pre-main-sequence phase?
- What is the evolutionary sequence of MYSOs?
- Do black holes limit SF, or does SF limit black-hole growth?
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- How did Galactic globular clusters form? Why don't they form today?
- Relation of massive star, binary, and cluster formation to NS and BH mergers
- (Multi-Messenger astronomy: GW, NS, and BH-NH mergers. post-MS mergers?
Stellar collisions? =? gravity waves, neutrino bursts?)

EXO-PLANETS & SOLAR SYSTEM

- Do planets form as companions? e.g. failed stars which migrate in?
- The role of dust opacity evolution in core formation.
- "Initial conditions: for planet, BD, and secondary formation.
- Do planets and stars form by similar mechanisms?
- Need better simulations.
- Is there life on other planets? What type? How common?
- How do we relate star formation/ISM studies planet formation, disks, and exoplanets?
- Explaining the formation of Earth & Earth-like planets around stable stars with water

COSMIC EVOLUTION OF STAR FORMATION

- What is the relationship between star formation in the current and early Universe?
- How good a guide is local star formation to the typical environment of star formation in the Universe (which is $z > 1$)?
- Are there scale invariant processes linking galaxy formation and star formations?
- Are colliding flows \Rightarrow sheets \Rightarrow filaments \Rightarrow clumps \Rightarrow cores \Rightarrow stars, clusters similar to "Zeldovich pancakes" in galaxy formation?

THEORY AND MODELING

- How reproducible of numerical models?
- Exploitation of multi-wavelength & large data ("astro-informatics")
- Statistics, AI, and machine learning for extracting data from large surveys and data sets
- The roles of DM and DE in galaxy formation and how this impacts star formation
- Larger scale radiation-MHD/Hydro, with self gravity, chemistry, heating & cooling, and RT. (Moore's Law, GPUs, etc to the rescue?)
- A focus on outliers breaking theories.
- Cross-talk between (sub)fields, not only observations \Leftrightarrow theory \Leftrightarrow numerics, Galactic \Leftrightarrow extragalactic, cores \Leftrightarrow clouds \Leftrightarrow galaxies.
- Modeling the evolution of SF filaments including B-fields, gas dynamics and feedback, in the regime of "massive star formation"
- Constraining cluster formation mechanisms/theories in the Milky Way in the era of Gaia / ALMA.

Challenges for the next decades:

- mm sub-mm proper motions (ALMA, NOEMA, ngVLA, +) => 6D phase-space
- Beyond ALMA/Spitzer/Herschel: 50+ meter mm/IR
- Star-formation community response be to the next US decadal survey be?
- Future facilities do we need? SKA? Space interferometers at visual to IR? Giant space telescopes? The "Goldin Dream Telescope"?
- "Breakthrough Starshot" & "Breakthrough Listen" ? (Milner Foundation)
- Giga-star synoptic spectroscopy from visual to near- IR (SDSS-V)
... and at all wavelengths! Transients at FIR, sub-mm, mm, radio, x-ray. ...
- Funding (can we afford more billion Euro / Pound / Dollar facilities?)
- Mass-market products (CMOS, Dragonfly, and commercial optics).
A ~10 meter by combining signals from 2,000 C-14s + CMOS
- Polarization and Zeeman splitting => B in 3D
- Mapping the gravitational potential and kinematics / dynamics.
- Too much data / too little brainpower !

From Hans:

- Where do most of the low-mass field stars originate?
- Is multiplicity a fundamental property of massive star formation?
- Is there a pre-MS phase for massive stars?
- What is the difference in initial conditions between dense OB clusters and more dispersed OB associations? (Gaia DR2)
- Is there any dynamical evidence for triggered star formation?
- What is the star formation law in dense gas?
- What is IMF in high-z starbursts?
- What do astrochemical observations tell us about star formation?
- What is going on in the Galactic Center? CMZ, CND, nuclear cluster?

