JD3

Massive Star Birth

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Rationale for the Joint Discussion

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Abstract. This Joint Discussion (JD) will consider the birth processes of massive stars. While similar phenomena (e.g., accretion discs, outflows, etc.) are found in low mass star formation, additional physics must be considered given the ionization of the interstellar environment by Lyman continuum photons, stellar winds from the hot star(s), and their deeper gravitational potentials. This JD will bring together experts from several disparate astronomical communities: stellar astrophysics, interstellar medium, radio astronomy, and stellar dynamics. The concept is to contrast observations of very young stars and star formation regions over various wavelengths with theoretical expectations.

The birth places of massive stars are in molecular cloud cores, but stars newly born within these regions are initially optically shrouded by the dust in the natal cloud. Massive stars, those of types O and B, are typically formed together in loose, or tight, groupings of associations or clusters. These hot and luminous stars have a profound effect on their local environments from their extensive Lyman continuum luminosity and strong stellar winds. Due to the large gravitational potentials of the central stars, all dynamical processes occur on shorter time scales than those near low mass proto stars. This has the consequence that the neighborhood of massive protostars is a very dynamic place in which gas velocities, densities and temperatures are expected to change by orders of magnitude within a radius less than 10^{16} cm. Changes of the ionization state of the gas and the temperature and properties of the dust are also expected to change dramatically in the neighborhood of massive protostars.

In an oversimplified early evolution scenario one would imagine that the photons dissociate, excite, and ionize the local material and the stellar winds will blow this away from the formation sites. Thus the initial birth processes are highly time dependent, and dynamical effects from the ensemble of hot stars probably play a major role in the overall formation processes. Additionally, individual protostars are following their own initial evolution from collapse, contraction, disc accretion, and possibly growth from mergers of lower mass objects, towards necular ignition. It is desireous to investigate the properties of giant molecular clouds that are now forming stars along with the resultant HII regions. These give estimates of the total numbers of stars potentially or already present.

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Observations of the earliest, most deeply embedded stages of massive star formation are only just becoming feasible with (sub)millimeter and mid-infrared telescopes. These objects are still so young that little or no radio continuum is detected. They are characterized by strong water masers and a rich, time-dependent chemistry in their surrounding envelopes. The formation of these "hot cores" and their evolution to the HII region stage is still poorly understood, and a thorough discussion of the latest observational and theoretical results is warranted. For molecular core clouds one would like to evaluate the importance of oblateness and if the distribution of water and methanol masers, which are often observed to have linear distributions on the sky, are indicative of "edge-on" geometry.

Ultra compact (UC) HII regions represent a well known early phase in the evolution of massive stars. Statistically, there are far too many of them to be consistent with the expectations from classical Strömgren theory, thus this phase lasts on average about 100 times longer than expected from the sound crossing times. Numerous postulates for the lifetime of UCHII regions have been proposed but no general consensus has yet emerged. The limited number of morphologies of UCHII regions and their dynamics (expansion rates, rotation, turbulent motions, etc.) still require further efforts.

A very general issue to be considered is the similarities and differences between massive and low mass star formation; for the latter, there has been considerable observational and theoretical progress in the last decade. So far, the evidence for the presence of discs around massive young stars has been controversial. Are they a necessary phase of massive star birth, and if so, how can we detect them? Are collimated polar outlows (jets) a necessary consequence of star birth and star formation and, if so, what is the physics of the outflow formation and collimation? Of the known outflow sources, can we distinguish between well collimated jets with entrained ISM or simply outflows with wide opening-angles in which most of the outflow material is diverted from in-falling gas? Could mergers of lower mass objects be an important formation mechanism for massive stars?

The role of the ionizing photons from massive hot stars is poorly understood in terms of star formation. On what time scale would they photoevaporate stellar discs? How do they affect the surrounding envelopes, and how many photons are "leaking out"? During the UCHII region phase there are still many unresolved issues among which are: the lifetime problem; the origin of possibly extended hard X-ray emission; the tight correlation of mass outflow rates with bolometric luminosity; the origin of the mass in the bipolar outflows; the identification of the sources of massive outflows (i.e., a massive protostar or a low mass star close by?); etc.

While many of the overall properties of the dust and gas in giant HII regions are well known from radio and IR wavelengths, it is only recently that individual exciting stars have been identified and classified through near IR photometry and spectroscopy. There is strong evidence from observations of M17 that the earliest type O stars are free of their natal dust clouds, while somewhat less luminous objects still have disc geometry. It is expected that more extensive near IR photometry and spectroscopy of additional Galactic HII regions will become available shortly. These observations, and others, can be used to confront the current paradigms of massive star formation.

During the past few years, observational and theoretical progress in star formation has been substantial, especially for low mass objects. We feel the time is now ripe to consider the specific topic of massive star birth. By bringing together experts in various subdisciplines for a one day Joint Discussion, we believe that: 1) a better understanding of the problems of massive star formation can be achieved; 2) an assessment of where we are in solving those problems will result; and 3) ideas for future programs to attach remaining problems will follow.