OBSERVATIONAL EVIDENCE FOR SUPERNova-INDUCED STAR FORMATION.


It has often been suggested that a supernova (SN) explosion might act as a trigger for star formation by compressing clouds in the surrounding interstellar medium (1, 2, 3). Recently Cameron and Truran (4) have argued that isotopic anomalies and extinct radioactivities in solar system material might imply a similar origin for the solar system. In spite of the importance and theoretical attractiveness of this idea very little direct observational evidence has been advanced to support it.

In this paper we present observational evidence that star formation in the young association CMa R1 was initiated by an SN explosion (probably of Type II).

CMa R1 is an R association (5, 6, 7) which contains two classical Herbig-emission stars (Z CMa and HD53367) and several other extremely young stellar objects which have likely ages around 10^5 to 10^6 years. It is located at the edge of a large-scale ring of emission nebulosity (see Fig. 1). The form of the ring, which is also seen at radio wavelengths (8), and the absence of luminous stellar objects at its center suggest that it may be a relatively old supernova remnant. This suggestion is greatly strengthened by our discovery of an expanding neutral hydrogen shell which is evident in the 21-cm hydrogen survey of Weaver and Williams (9). Such shells are found around old supernova remnants (10). Furthermore we have discovered a "runaway" star, HD54462, in CMa OB1. Such objects are commonly believed to be escaped members of binary systems in which one star has become an SN.

While the location of the recently formed star at the edge of a supernova remnant (SNR) by itself suggests a causal connection, this connection is strengthened by the close compatibility between the age of the stars and the age of the SNR. We derive the latter quantity by appealing to numerical models of the expansion of an SNR in a uniform medium calculated by Chevalier (2). With the measured radius of the remnant (30 pc) and expansion velocity (32 km/sec) we derive an age for the SNR of t = 6 x 10^5 years. This number is relatively insensitive to any large scale inhomogeneities which might have existed in the initial density distribution and we estimate its accuracy to be ~ 30%. We also estimate the initial outburst energy of the SN to be of order 5 x 10^5 ergs. This depends more sensitively on the initial density of the interstellar medium than does the age estimate and is, therefore, less accurately determined. It does however suggest that the SN was of Type II (probably a member of CMa OB1). If the runaway star can be conclusively tied to this SN event, then it must have been of Type II.

We feel that the location of the stars with respect to the SNR and the time scale compatibility strongly support the hypothesis that an SN event triggered star formation in CMa R1.

The existence of loop, ring, and expanding shell structures in other OB associations (11, 12) suggests that CMa R1 may not be an isolated example of this phenomenon but simply one where circumstances (age, geometry, galactic location, etc.) were favorable for recognizing the physical process involved. In particular, several features of the Orion nebula, including Barnard's loop...
and the runaway stars can be explained by this hypothesis.

The observational evidence presented here places the hypothesis of supernova-induced star formation on solid foundations, and thus supports the feasibility of Cameron and Truran's model of a supernova triggered solar system.

References:
Figure 1. The QCE K Ring. This composite was made from two adjacent pixels.

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