論文内容の要旨

論文題目　An Infrared Study of the Highest Density Cluster Core in R CrA Star-Forming Region
(R CrA 星形成領域で最も密度が高いコアについての赤外線による研究)

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Observations in the last ~ 20 years revealed that the vast majority of the stars are formed within clusters. The stellar clusters are formed within massive molecular cloud cores, but little is known about how the cores fragments into a cluster of stars. Recent numerical simulations and several observations suggest that the stellar number density could be extremely large, affecting the properties of formed star considerablly.

Observation of such state of high stellar number density deeply embedded within massive cores is very challenging as both high spatial resolution and high sensitivity to penetrate the high extinction of gas are needed. Recent advent in the observing capabilities, however, are now starting to allow us to attempt to peek into such systems.

In this thesis, one of the closest star-forming region, R CrA star-forming region is studied in detail. The region contains a massive core that is actively producing an extremely young stellar cluster. Our study focuses on the central high gas density region, where no thorough study of stellar contents have been made.

First, we conducted near- and thermal-infrared imaging observations of the central high gas-density region with the 8.2-m Subaru Telescope and its various instruments. Our observations conducted in K-band (2.2μm), L'-band (3.8μm), N-band (11.7μm) and Q-band (24.5μm) detected a total of five objects within the 3000 AU-radius disk-like structure around IRS 7(A) observed in HCO^+ molecular lines. The detected objects are roughly aligned along the major axis of the disk structure, with a typical separation of 1000 AU from each other. Among the 5 detected objects are two previously known deeply embedded sources, IRS 7A and IRS 7B, which are also known to be prominent X-ray emitters. In this chapter, we also re-analysized IRAS data of the region, which

revealed that IRS 7A is the highly likely dominant source of the 60 and 100 μm fluxes measured by IRAS, which have been attributed to either R CrA or the cold dust clump $\sim$ 20″ south of IRS 7A (viz., SMM1A and MMS13) in the past literatures. IRS 7A and IRS 7B shows remarkable similarity for their entire spectrum, and three observational classifications (infrared spectral index, T_{bol} and L_{smm}/L_{bol}) indicate that both objects are close to the borderline between Class 0 and Class I, with slightly more weight toward the Class 0 regime.

Our finding revealed that the total number of objects in the central 5000 AU scale volume can now be as large as $\sim$ 10 when the sources whose existence has been inferred from other observations but not detected in our observations are taken into account, yielding the stellar number density of the region well in excess of 10^5 pc^{-3}.

The densest part of the R CrA core was also observed at the H_2 S(1) line with the Subaru Telescope and CISCO. Our observation revealed a group of Herbig-Haro objects with complex morphology emanating from the vicinities of the IRS 7 system, which contain embedded population of sources studied in our thermal infrared observations. The distribution of these HH objects coincide with the overall shape of the single most dominant molecular outflow of the region, suspected to emanate from the IRS 7 region. The distribution of the Herbig-Haro objects in the region suggest that the central disk-like structure observed in radio molecular lines at the IRS 7 region is the common origin of many Herbig-Haro objects in the region.

An adaptive optics (AO) imaging observation of the center of the Corona Australis star-forming region is also presented. The AO observation was conducted by taking the advantage of the fact that the optically bright Herbig Ae star R CrA is located at the center of the protostar cluster, and by using the object as the guide star for the AO wavefront sensing. Our observation in H, K, and L′-bands carried out at the Subaru Telescope with IRCS and the Subaru adaptive optics system achieved a resolution of $\sim$0.20 arcsec ($\sim$25 AU, assuming a distance of 130 pc) in three bands. The field of view, covering 1′ $\times$ 1′ around R CrA, contains two protostars that are known prior to this study, viz., IRS 7(A) and IRS 9, as well as some other sources found in the previous chapters. The extremely young protostar IRS 7 (class 0-I) was clearly found to have an elongated structure in the near-infrared wavelength. The size of the elongation is about 0.55 arcsec FWHM ($\sim$70 AU) along the major axis, and its position angle ($\sim$ 140 $\pm$ 5 degrees) is consistent with that of the rotating molecular disk-like structure around IRS 7. This new observation provides an additional evidence for the physical connection between the protostar and the molecular structure. The elongation is not symmetric along the major axis of the elongation. Another class 0-I protostar IRS 9 did not show any signs of extended structure or companions in their vicinities at our resolution and sensitivities. Four, possibly five, additional objects are also detected, and the nature of these object are also discussed.

In summary, our observations revealed a concentrated population of extremely young stellar sources within or near the central disk-like system surrounding the likely Class 0 protostar IRS 7A, and exhibit high level of outflow activity. The stellar number density of the central region exceeds $10^{5\ -3}$ pc. Our observations provides an example that star-formation within clusters could be quite different compare to the isolated-mode of star-formation.