THE STAR FORMATION NEWSLETTER

An electronic publication dedicated to early stellar evolution and molecular clouds

No. 192 — 6 Dec 2008 Editor: Bo Reipurth (reipurth@ifa.hawaii.edu)

Special Issue

Handbook of Star Forming Regions

Edited by Bo Reipurth

The Handbook describes the ∼60 most important star forming regions within approximately 2 kpc, and has been written by a team of 105 authors with expertise in the individual regions. It consists of two full color volumes, one for the northern and one for the southern hemisphere, with a total of over 1900 pages. The Handbook aims to be a source of comprehensive factual information about each region, with very extensive references to the literature. The development of our understanding of a given region is outlined, and hence many of the earliest studies are, if not discussed, then at least mentioned, even if they are only of historical interest today. Young low- and high-mass populations are discussed, as well as the molecular and ionized gas. The text is supported by extensive use of figures and tables. Authors have been encouraged to complete their chapters with a section on individual objects of special interest. Little emphasis is placed on more general discussions of star formation processes and the properties of young stars, subjects that are well covered elsewhere. The Handbook will thus serve as a reference guide for researchers and students embarking on a study of one or more of these regions, and will hopefully also inspire new work to be done where information is clearly missing. In order to keep the Handbook within some reasonable limits, it was from the beginning decided to limit regions to those closer than approximately 2 kpc. Such a limit of course means that certain famous and important regions are omitted, like NGC 3603, but it is not completely arbitrary, because at around 2 kpc sensitivity and resolution issues start to make more detailed observations of low mass populations very difficult. All chapters are *a jour* with the literature up to the early summer of 2008. An effort has been made to use illustrations that are helpful to get an overview of important areas or objects in each individual region. Images covering more than a degree on the sky are not always easy to find, but in recent years advanced amateur astronomers have begun to obtain stunning CCD images, and results from some of the best astrophotographers adorn the Handbook. Altogether, the Handbook provides a unique and detailed presentation of our current knowledge about the nearest and most important star forming regions.

Astronomical Society of the Pacific

ISBN 978-1-58381-670-7, hardbound, 1023 pages, 2008, US$80
ISBN 978-1-58381-671-4, hardbound, 890 pages, 2008, US$80

Available from http://www.astrosociety.org/online-store/scstore/p-MPS01.html

or from service@astrosociety.org

With purchase of the books also comes access to electronic versions of the books.

Volume 1

Star Forming Regions along the Milky Way: A Panoramic View

Axel Mellinger[1,2]

[1] Institute for Physics and Astronomy, University of Potsdam, Karl-Liebknecht-Str. 24-25, 14476 Potsdam-Golm, Germany
[2] Present address: Department of Physics, Central Michigan University, Mount Pleasant, MI 48859, USA

E-mail contact: axm *at* uni-potsdam.de

The location of the star forming regions covered in this book is shown superimposed on a panoramic image of the Milky Way.

Where are all the Young Stars in Aquila?

L. Prato[1], **E.L. Rice**[2] **and T.M. Dame**[3]

[1] Lowell Observatory, 1400 West Mars Hill Road, Flagstaff, AZ 86001, USA
[2] Department of Physics & Astronomy, UCLA, Los Angeles, CA 90095-1547, USA
[3] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA

E-mail contact: lprato *at* lowell.edu

The high Galactic longitude end of the Aquila Rift comprises the large Aquila molecular cloud complex, however, few young stars are known to be located in the area, and only one is directly associated with the Rift. In contrast, the Serpens star-forming region at the low Galactic longitude end of the Rift contains hundreds of young stars. We review studies of the raw molecular material and describe searches for young objects in the Aquila clouds. The characteristics of the known young stars and associated jets and outflows are also provided. Finally, we suggest some possible explanations for the dearth of star formation in this gas-rich region and propose some future observations to examine this mystery further.

Star Formation and Young Clusters in Cygnus

Bo Reipurth[1] **and Nicola Schneider**[2]

[1]Institute for Astronomy, University of Hawaii, 640 N. Aohoku Place, Hilo, HI 96720, USA
[2] SAp/CEA Saclay, Laboratoire AIM CNRS, Université Paris Diderot, France

E-mail contact: reipurth *at* ifa.hawaii.edu

The Great Cygnus Rift harbors numerous very active regions of current or recent star formation. In this part of the sky we look down a spiral arm, so regions from only a few hundred pc to several kpc are superposed. The North America and Pelican nebulae, parts of a single giant HII region, are the best known of the Cygnus regions of star formation and are located at a distance of only about 600 pc. Adjacent, but at a distance of about 1.7 kpc, is the Cygnus X region, a $\sim 10^{\circ}$ complex of actively star forming molecular clouds and young clusters. The most massive of these clusters is the 3-4 Myr old Cyg OB2 association, containing several thousand OB stars and akin to the young globular clusters in the LMC. The rich populations of young low and high mass stars and protostars associated with the massive cloud complexes in Cygnus are largely unexplored and deserve systematic study.

S106

Klaus Hodapp[1] **and Nicola Schneider**[2]

[1] Institute for Astronomy, University of Hawaii, 640 N. A'ohoku Place, Hilo, HI 96720, USA
[2] IRFU/SAp CEA/DSM, Lab. AIM CNRS, 91191 Gif-sur-Yvette, France

E-mail contact: hodapp *at* ifa.hawaii.edu

S106 is a bipolar nebula illuminated and excited by a central star called S106 IR. Depending on its distance (literature

values range from 500 pc to 5.7 kpc) this star is of late O to early B spectral type. There is evidence that S106 is physically associated with the molecular cloud complex of Cygnus X. The bipolar nebula is the dominant feature in an embedded cluster of young stars forming in a molecular cloud. The bipolar morphology is visible from optical wavelengths into radio wavelengths, implying that it is not caused by foreground extinction. Instead, it is caused by the shadowing effect of a small disk surrounding the exciting star that projects into the surrounding molecular cloud and confines ionizing radiation to the lobes. With the discovery of new star formation sites in S106, i.e. YSOs in the S106 cluster, additional sub-clusters, the Class 0 source S106 FIR, and dense cold cores as reservoirs for new stars, S106 can nowadays be seen as a whole region of active star formation. This view revises earlier interpretations of radio and molecular line observations that saw S106 IR as a single massive protostar with a large accretion disk.

Young Stars and Molecular Clouds in the IC 5146 Region

G.H. Herbig[1] and Bo Reipurth[2]

[1] Institute for Astronomy, University of Hawaii, 2680 Woodlawn Drive, Honolulu, HI 96822, USA
[2] Institute for Astronomy, University of Hawaii, 640 N. Aohoku Place, Hilo, HI 96720, USA

E-mail contact: herbig *at* ifa.hawaii.edu

IC 5146 is both a reflection nebula and an HII region surrounding the B0 V star BD+46^o 3474. The region is relatively nearby at 1.2 kpc. It has attracted considerable attention, and has been studied at optical, infrared, millimeter, and radio wavelengths. A substantial population of young low-mass stars exists in the region. IC 5146 is located at the eastern end of a more than 1 degree long cloud filament, which harbors scattered star formation, including the FU Orionis star Elias 1-12 = V1735 Cyg.

The Lacerta OB1 Association

W.P. Chen[1] and H.T. Lee[2]

[1] Institute of Astronomy and Department of Physics, National Central University, 300 Jhongda Road, Jhongli 32054, Taiwan
[2] Institute of Astronomy and Astrophysics, Academia Sinica, P.O. Box 23–141, Taipei 10617, Taiwan

E-mail contact: wchen *at* astro.ncu.edu.tw

Lac OB1 is a nearby OB association in its final stage of star formation. While the member stars suggest an expansion time scale of tens of Myr, the latest star formation episode, as manifested by the existence of massive and pre-main sequence stars, took place no more than a few Myr ago. The remnant molecular clouds in the region provide evidence of starbirth triggered by massive stars.

Star Forming Regions in Cepheus

Mária Kun[1], Zoltán T. Kiss[2], and Zoltán Balog[3]

[1] Konkoly Observatory, H-1525 Budapest, P.O. Box 67, Hungary
[2] Baja Astronomical Observatory, P.O. Box 766, H-6500 Baja, Hungary
[3] Steward Observatory, University of Arizona, 933 N. Cherry Av., Tucson AZ 85721, USA

E-mail contact: kun *at* konkoly.hu

The northern Milky Way in the constellation of Cepheus ($100\,\mathrm{deg} \leq l \leq 120\,\mathrm{deg}; 0\,\mathrm{deg} \leq b \leq 20\,\mathrm{deg}$) contains several star forming regions. The molecular clouds of the Cepheus Flare region at $b > 10\,\mathrm{deg}$, are sites of low and intermediate mass star formation located between 200 and 450 pc from the Sun. Three nearby OB associations, Cep OB2, Cep OB3, Cep OB4, located at 600–800 pc, are each involved in forming stars, like the well known high mass star forming region S 140 at 900 pc. The reflection nebula NGC 7129 around 1 kpc harbors young, compact clusters of low and intermediate mass stars. The giant star forming complex NGC 7538 and the young open cluster NGC 7380, associated with the Perseus arm, are located at $d > 2\,\mathrm{kpc}$.

Star Forming Regions in Cassiopeia

Mária Kun[1]

[1] Konkoly Observatory, H-1525 Budapest, P.O. Box 67, Hungary

E-mail contact: kun *at* konkoly.hu

This chapter describes the Galactic star forming regions in the constellation Cassiopeia, in the Galactic coordinate range 120 deg¡l¡130 deg, −5 deg¡b¡15 deg. At $|b| > 10$ deg the nearby clouds L 1333 and L 1340 are found in this region. The local arm of the Galaxy in Cassiopeia contains only a few star forming regions, smaller and less active than the OB associations of the neighboring Cepheus. Five members of this system, LkHα 198 and its environment, L 1287, L 1293, L 1302/NGC 255, and S 187 are discussed. Several more distant OB associations and giant star forming regions in Cassiopeia are associated with the Perseus arm at 2.0–3.0 kpc. Among these, the Herbig Be star MWC 1080 is discussed in this chapter.

Low and High Mass Star formation in the W3, W4, and W5 Regions

S.T. Megeath[1], L.K. Townsley[2], M.S. Oey[3] and A.R. Tieftrunk[4]

[1] Ritter Observatory, M.S. 113, Department of Physics and Astronomy, University of Toledo, Toledo, OH 43606-3390, USA
[2] Department of Astronomy and Astrophysics, 525 Davey Laboratory, Pennsylvania State University, University Park, PA 16802, USA
[3] Department of Astronomy, 830 Dennison Building, University of Michigan, Ann Arbor, MI 48109-1042, USA
[4] Im Acker 21b, 56072 Koblenz, Germany

E-mail contact: megeath *at* physics.utoledo.edu

Since their discovery, the W3, W4, and W5 regions have been extensively studied from multi-parsec down to 100 AU size scales. W3 contains one of the richest and best studied populations of young, deeply embedded massive stars within 2 kpc of the Sun. W4 is one of the nearest examples of a galactic superbubble powered by the winds and supernovae of OB stars. W3 and W5 contain new generations of star formation that appear to have been triggered by previous generations of OB stars. Although these regions have been primarily studied as sites of massive star formation, more recent work has also established the presence of thousands of young, low-mass stars. In total, these regions form an excellent laboratory to study the formation and early evolution of massive stars, the relationship between low- and high-mass star formation, and the role of feedback in regulating star formation.

Young Stars and Clouds in Camelopardalis

V. Straizys[1] and V. Laugalys[1]

[1] Institute of Theoretical Physics and Astronomy, Vilnius University, Gostauto 12, Vilnius LT-01108, Lithuania

E-mail contact: straizys *at* mserv.itpa.lt

Star formation in the Local spiral arm in the direction of the Galactic longitudes 132–158deg is reviewed. Recent star-forming activity in this Milky Way direction is evidenced by the presence here of the Cam OB1 association and dense dust and molecular clouds containing Hα emission stars, young irregular variables and infrared stellar objects. The clouds of the Local arm concentrate in two layers at 150–300 pc and $\sim$900 pc from the Sun. The Perseus arm objects in this direction are at a distance of about 2 kpc.

The Perseus Cloud

John Bally[1], Josh Walawender[2], Doug Johnstone[3], Helen Kirk[3] and Alyssa Goodman[4]

[1] Center for Astrophysics and Space Astronomy, University of Colorado, 389 UCB, Boulder, CO 80389, USA
[2] Institute for Astronomy, University of Hawaii, 640 N. Aohoku Pl., Hilo, HI 96720, USA
[3] National Research Council of Canada, Herzberg Institute for Astrophysics, 5071 W. Saanich Rd., Victoria ON V9E 2E7, Canada
[4] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA

E-mail contact: John.Bally *at* colorado.edu

The Perseus molecular cloud and its surroundings contain several regions of active or recent star formation lying within about 300 pc of the Sun. Roughly a dozen OB and over a thousand lower mass stars younger than 6 Myr make up the 50 pc diameter Perseus OB 2 association. Recent supernovae in the Per OB2 association drive an expanding HI supershell into the surrounding interstellar medium. A run-away star from this association, ξ Persi, illuminates and ionizes a portion of this ring, producing the California Nebula (NGC 1499, Sh-2 220). The 10^4 $M_\odot$ Perseus molecular cloud is the closest such object actively forming large numbers of low to intermediate-mass stars. The eastern end of the cloud is associated with the 2 – 4 Myr old cluster IC 348 that contains several hundred young stars. However, the western portion of the Perseus cloud contains the most active sites of current star formation, including the 150 member NGC 1333 cluster, the small stellar aggregates associated with Barnard 1, L1448, L1455, and additional cloud cores which are producing smaller groups of young stars. Narrow-band visual wavelength surveys have led to the discovery of over a hundred individual Herbig-Haro objects. Studies of outflows in the Perseus molecular cloud have illuminated their contribution to the generation of turbulent motions in the surrounding gas, the disruption of cloud cores, and the self regulation of star formation. In this review, we cover the region of the sky from about $l = 150°$ to 180° and $b = -30°$ to 0°, and the young stars, clusters, and clouds which lie between 200 and 400 pc from the Sun with ages of less than about 15 Myr with an emphasis on the Perseus molecular cloud. This is the sphere of influence of the Per OB2 association. We discuss the 20° diameter Per OB2 supershell, the OB association, its relationship to surrounding molecular gas, and on-going star formation within the Perseus molecular cloud.

NGC 1333: A Nearby Burst of Star Formation

J. Walawender[1], J. Bally[2], J. Di Francesco[3], J. Jorgensen[4], and K. Getman[5]

[1] University of Hawaii, Institute for Astronomy, 640 N. Aohoku Pl. Hilo, HI 96720, USA
[2] University of Colorado, Center for Astrophysics and Space Astronomy, 389 UCB, Boulder, CO 80309, USA
[3] Herzberg Institute of Astrophysics, National Research Council of Canada, 5071 West Saanich Road, Victoria, BC V9E 2E7, Canada
[4] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA
[5] Department of Astronomy and Astrophysics, Penn State University, 525 Davey Lab, University Park, PA 16802, USA

E-mail contact: joshw *at* ifa.hawaii.edu

NGC 1333 is the currently most active region of star formation in the Perseus molecular cloud. The presence of emission-line stars and Herbig-Haro objects first established NGC 1333 as an active region of star formation. Today, NGC 1333 is one of the best studied extremely young clusters of low to intermediate mass stars. This region is rich in sub-mm cores, embedded YSOs, radio continuum sources, masers, IRAS sources, SiO molecular jets, H_2 and HH shocks, molecular outflows, and the lobes of extinct outflows. Dozens of outflows from embedded and young cluster members criss-cross this region. While the complexity and confusion of sources and outflows has made it difficult to unravel the relations between various components, NGC 1333 has illuminated the roles of feedback and clustering phenomena in star formation.

Star Formation in IC 348

William Herbst[1]

[1] Astronomy Department, Wesleyan University, Middletown, CT 06459, USA

E-mail contact: wherbst *at* wesleyan.edu

A review of work on the small, compact, nearby young cluster IC 348 is given. This region is particularly important because it is well surveyed at a variety of wavelengths and intermediate in nature between dense clusters and loose associations. Its earliest type star is B5 and it contains a few hundred stellar members as well as some brown dwarfs, protostars, Herbig-Haro objects and starless sub-mm cores. The total mass of its components is $\sim$90 $M_\odot$, most of which is in the form of pre-main sequence stars. Perhaps the biggest challenge to work on the cluster is the relatively high and variable extinction (A_v=1-7 mag). Studies to date have provided particularly valuable insights into the initial mass function, disk lifetimes, stellar rotation properties, X-ray properties, outflows and substructure of the cluster. Results on the stellar component include the following: 1) the initial mass function matches that for field stars in

the stellar and brown dwarf regimes, 2) the fraction of stars with disks is probably normal for the cluster's age, 3) the rotation properties match those of the Orion Nebula Cluster and are significantly different, in the sense of slower rotation, than NGC 2264, 4) the X-ray properties of the stars appear normal for T Tauri stars. There is a ridge of high extinction that lies ∼10 arcmin (0.9 pc in projection) to the southwest of IC 348 and contains about a dozen Class 0 and I protostars as well as some Herbig-Haro objects and sub-mm cores. This region, which also contains the "Flying Ghost Nebula" and the well-studied object HH 211, clearly signals that star formation in this part of the Perseus dark clouds is not yet finished. An extensive kinematical study involving both proper motions and radial velocities for the 400 members of the cluster would be most desirable.

The LkHα 101 Cluster

Sean Andrews[1] **and Scott J. Wolk**[1]

[1] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA, 02138, USA

E-mail contact: sandrews *at* cfa.harvard.edu

In the infrared, the heavily reddened LkHα 101 is one of the brightest young stars in the sky. Situated just north of the Taurus-Auriga complex in the L1482 dark cloud, it appears to be an early B-type star that has been serendipitously exposed during a rarely observed stage of early evolution, revealing a remarkable spectrum and a directly-imaged circumstellar disk. While detailed studies of this star and its circumstellar environment have become increasingly sophisticated in the 50 years since Herbig (1956) first pointed it out, the true nature of the object still remains a mystery. Recent work has renewed focus on the young cluster of stars surrounding LkHα 101, and what it can tell us about the enigmatic source at its center (e.g., massive star formation timescales, clustered formation mechanisms). This latter effort certainly deserves more intensive study. We describe the current knowledge of this region and point out interesting work that could be done in the future.

Low Mass Star Formation in the Taurus-Auriga Clouds

Scott Kenyon[1]**, Mercedes Gómez**[2] **and Barbara A. Whitney**[3]

[1] Smithsonian Astrophysical Observatory, 60 Garden Street, Cambridge, MA 02138, USA
[2] Observatorio Astronómico, Universidad Nacional de Córdoba, Laprida 854, 5000 Córdoba, Argentina
[3] Space Science Institute, 4750 Walnut Street, Suite 205, Boulder, CO 80301, USA

E-mail contact: skenyon *at* cfa.harvard.edu

We review the history and structure of star formation in the Taurus-Auriga dark clouds. Our discussion includes a summary of the macroscopic cloud properties, the population of single and binary pre-main sequence stars, the properties of jets and outflows, and detailed summaries of selected individual objects. We include comprehensive tables of dark clouds, young stars, and jets in the clouds.

Overview of the Orion Complex

John Bally[1]

[1] Center for Astrophysics and Apace Astronomy, University of Colorado, Boulder, CO 80389, USA

E-mail contact: John.Bally *at* colorado.edu

The Orion star formation complex is the nearest region of on-going star formation that continues to produce both low and high mass stars. Orion is discussed in the larger context of star formation in the Solar vicinity over the last 100 Myr. The Orion complex is located on the far side of the Gould's Belt system of clouds and young stars through which our Solar system is drifting. A review is given of the overall structure and properties of the Orion star forming complex, the best studied OB association. Over the last 12 Myr, Orion has given birth to at least ten thousand stars contained in a half dozen sub-groups and short-lived clusters. The Orion OB association has been the source of several massive, high-velocity run-away stars, including μ Columbae and AE Auriga. Some of Orion's most massive members died in supernova explosions that created the 300 pc diameter Orion / Eridanus super-bubble whose near wall may be as close as 180 pc. The combined effects of UV radiation, stellar winds, and supernovae have impacted surviving molecular clouds in Orion. The large Orion A, IC 2118 molecular clouds and dozens of smaller clouds strewn

throughout the interior of the superbubble have cometary shapes pointing back towards the center of the Orion OB association. Most are forming stars in the compressed layers facing the bubble interior.

Star Formation in the Orion Nebula I: Stellar Content

August Muench[1], Konstantin Getman[2], Lynne Hillenbrand[3], and Thomas Preibisch[4]

[1] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA
[2] Department of Astronomy and Astrophysics, Pennsylvania State University, 525 Davey Laboratory, University Park, PA 16802, USA
[3] Department of Astronomy, California Institute of Technology, Mail Code 105-24, Pasadena, CA 91125, USA
[4] Universitäts-Sternwarte München, Scheinerstr. 1, D-81679 München, Germany

E-mail contact: gmuench *at* cfa.harvard.edu

The Orion Nebula is one of the most frequently observed nearby (< 1 kiloparsec) star forming regions and, consequently, the subject of a large bibliography of observations and interpretation. The summary in this chapter is bounded spatially by the blister HII region, with sources beyond the central nebula that are part of the same dynamical clustering covered in other chapters in this book. Herein are discussed panchromatic observations of the massive OB stars, the general T Tauri population, the sub-stellar sources and variable stars within the Orion Nebula. First, a brief history of 400 years of observation of the Nebula is presented. As this history is marked clearly by revelations provided in each age of new technology, recent ultra-deep X-ray surveys and high resolution multi-epoch monitoring of massive binary systems and radio stars receive special attention in this review. Topics discussed include the kinematics, multiplicity, mass distribution, rotation, and circumstellar characteristics of the pre-main sequence population. Also treated in depth are historical and current constraints on the distance to the Orion Nebula Cluster; a long standing 10-20% uncertainty has only recently begun to converge on a value near ~ 400 parsecs. Complementing the current review of the stellar population is a companion chapter reviewing the molecular cloud, ionized HII region and the youngest protostellar sources.

Star Formation in the Orion Nebula II: Gas, Dust, Proplyds and Outflows

C.R. O'Dell[1], August Muench[2], Nathan Smith[3], and Luis Zapata[4]

[1] Department of Physics and Astronomy, Vanderbilt University, Box 1807-B, Nashville, TN 37235, USA
[2] Harvard-Smithsonian Center for Astrophysics 60 Garden Street, Cambridge, MA 02138, USA
[3] Astronomy Department, University of California at Berkeley, 601 Campbell Hall, Berkeley, CA 94720, USA
[4] Max Planck Institute for Radio Astronomy, Auf dem Hügel 69, 53121 Bonn, Germany

E-mail contact: cro *at* orion.phy.vanderbilt.edu

The visually familiar Trapezium cluster is but one of three centers of recent star formation in the Orion Nebula, with the other two still embedded in its host molecular cloud. The Orion Nebula was produced when the hottest stars in the Orion Nebula Cluster photoionized local gaseous material, forming an open cavity around the Trapezium stars, with a background blister of ionized gas, then a photon dominated region beyond that. On the near side there is a neutral veil of material. The cluster members include many proplyds, young stellar objects that are rendered more visible by being in or near an H II region. Their existence is an argument that the most massive stars in the cluster formed only recently. The second-most luminous star formation center is in the BN-KL region and is embedded in the molecular cloud, which means that it is seen only in X-ray, infrared, and radio wavelengths. There are arguments that it experienced a major energetic event 500–1000 years ago, producing runaway objects and a host of expanding fingers of gas and dust. The third center of star formation, Orion-S, lies only slightly behind the photon dominated region and produces multiple outflows, most of which are bipolar, and are seen in molecular and ionized atomic emission. The proximity of the Orion Nebula and its conditions of low extinction mean that it is the richest region of coll ejecta from pre-main sequence low-mass stars.

The Orion Molecular Cloud 2/3 and NGC 1977 Regions

Dawn E. Peterson[1] and S. Thomas Megeath[2]

[1] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA

[2] Ritter Observatory MS 113, University of Toledo, 2801 W. Bancroft St, Toledo, OH 43606, USA

E-mail contact: dpeterson *at* cfa.harvard.edu

The Orion Molecular Cloud 2/3 region (hereafter, OMC-2/3) and the reflection nebula NGC 1977 encompass a section of the Orion A molecular cloud undergoing vigorous star forming activity. One of the richest assemblages of protostars in the nearest 500 pc is seen in OMC-2/3, while NGC 1977 contains a cluster of over 100 young stars. In this review, we present a census of the protostars, pre-main sequence stars, and young brown dwarfs in these regions. These are identified through sub-millimeter surveys, far-red to near-infrared imaging and spectroscopy with ground-based telescopes, mid-infrared photometry from the *Spitzer Space Telescope*, and X-ray observations made with the Chandra X-ray Observatory. We present an overview of the distribution of molecular gas associated with these regions and the rich complex of shock heated nebulae created by the young stars interacting with the molecular gas. Finally, we discuss the relationship of OMC-2/3 and NGC 1977 to the neighboring Orion Nebula Cluster and the Orion OB1 association.

Low Mass Star Formation in the Lynds 1641 Molecular Cloud

L.E. Allen[1] and C.J. Davis[2]

[1] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA
[2] Joint Astronomy Centre, 660 North A'ohōkū Place, University Park, Hilo, Hawaii 96720, USA

E-mail contact: leallen *at* cfa.harvard.edu

The Lynds 1641 cloud makes up the bulk of Orion A south of the Orion Nebula Cluster. Although it contains no rich clusters comparable to the ONC, it is forming stars in numerous dense molecular cores found primarily along a ridge of gas that extends the length of the cloud (approximately 2.5 degrees). Optical, X-ray, and infrared surveys have detected hundreds of young, predominantly low-mass stars. Most of the protostars are clustered in small groups or aggregates of N=5–40 members, but the more evolved T Tauri stars appear to be located both in and around these aggregates. L 1641 has thus become a case study for the relative importance of "distributed" vs. "clustered" star formation. Recent results from the *Spitzer Space Telescope* survey of L 1641 confirms the existence of a significant distributed population, in which 44% of the young stars are in low surface density regions of fewer than 10 stars/pc^2. L 1641 is extremely rich in molecular outflows and HH–objects, containing as many as 85 molecular outflows and many HH–shocks. Some of the HH flows are quite spectacular and at least a few comprise pc-scale systems, most notably the HH 303/310 outflow, whose largest lobe extends 6.3 pc from the driving star.

Star Formation in NGC 2023, NGC 2024, and Southern L1630

Michael R. Meyer[1], Kevin Flaherty[1], Joanna L. Levine[2], Elizabeth A. Lada[2], Brendan P. Bowler[3], and Ryo Kandori[4]

[1] Steward Observatory, The University of Arizona, Tucson, AZ 85721, USA
[2] Department of Astronomy, 211 Space Sciences Building, University of Florida, Gainesville, Florida 32611, USA
[3] Institute for Astronomy, University of Hawaii, Honolulu, HI 96822, USA
[4] Optical and Infrared Astronomy Division, National Astronomical Observatory of Japan, Osawa 2-21-1, Mitaka, Tokyo 181-8588, Japan

E-mail contact: mmeyer *at* as.arizona.edu

We review star formation in the southern L1630 molecular cloud (also known as Orion B) as well as the relationship between the young stellar populations and the remnant molecular gas. We begin with an historical introduction to the region, and proceed to discuss recent developments in the study of NGC 2023, NGC 2024, and star formation associated with the Horsehead Nebula. Next we consider the distributed mode of star formation in the L1630 cloud, and conclude with a synthesis of star–forming activity in the region. By comparing and contrasting star formation in Orion B with that found in Orion A, one hopes to discern differences as a function of local initial conditions.

Star Formation in NGC 2068, NGC 2071, and Northern L1630

A.G. Gibb[1]

[1] Department of Physics and Astronomy, University of British Columbia, 6224 Agricultural Road, Vancouver, BC

V6T 1Z1, Canada

E-mail contact: agg *at* phas.ubc.ca

The L 1630 giant molecular cloud in Orion is a well-studied region of star formation. This review summarizes the main properties of the molecular cloud, describing its structure and appearance at various wavelengths; the major centres of star formation in the northern half of the cloud are reviewed and discussed, and descriptions given of the main individual sources of particular interest. An examination of distance estimates yields a mean value of ∼400 pc to L 1630, although values of 390 to 415 pc may be more applicable to the north and south ends of the cloud, respectively. The cloud is elongated, and has two well-defined centres of ongoing star formation, each of which is in turn composed of 2 or 3 regions of active star formation: NGC 2071, NGC 2068, HH 24–26, NGC 2023 and NGC 2024. Detailed studies of these regions have revealed sources at all stages of pre-main sequence evolution from Class 0 protostars to T Tauri stars. The majority of such sources in northern L 1630 are of low luminosity (less than $\sim 100\,L_\odot$). The recent outburst from IRAS 05436−0007 (V 1647 Ori) has attracted much attention, and appears to be a low-luminosity protostar, perhaps in a transition phase from Class I to Class II. The diffuse ionized region known as Barnard's Loop crosses the face of the cloud but does not appear to be interacting dynamically with L 1630.

The σ Orionis Cluster

Frederick M. Walter[1], William H. Sherry[2], Scott J. Wolk[3], and Nancy R. Adams[3]

[1] Stony Brook University, Stony Brook, NY 11794-3800, USA
[2] National Solar Observatory, Tucson AZ, USA
[3] Center for Astrophysics, Cambridge MA 02139, USA

E-mail contact: fwalter *at* astro.sunysb.edu

The σ Orionis cluster is the group of stars surrounding the high mass σ Ori stellar system. It is kinematically distinct from the Orion OB1a and OB1b associations, against which it is projected. The cluster could contain up to ∼700 stars and substellar mass objects, with a total mass of about 225 $M_\odot$ within a radius of about 30 arcmin. The age is 2–3 million years. The distance, from main sequence fitting corrected for the sub-solar metallicity, is 420±30 pc. The mass function is similar to the field star mass function, and has been traced well into the planetary mass regime. The disk fraction is normal for its age. The cluster appears to be an older and less massive analog of the Orion Nebula Cluster.

The λ Orionis Star Forming Region

Robert D. Mathieu[1]

[1] Department of Astronomy, University of Wisconsin - Madison, Madison, WI 53706, USA

E-mail contact: mathieu *at* astro.wisc.edu

Around the O8 star λ Orionis is a highly evolved star-forming region, comprising recently formed stars from 0.2 $M_\odot$ to 24 $M_\odot$ and dark clouds actively forming stars, all within a 30-pc radius ring of dust and neutral and molecular hydrogen. The spatial and age distributions of the stars show that originally star formation occurred in an elongated giant molecular cloud, with the most massive stars forming in a dense central core. A supernova is suggested as the mechanism that terminated star formation in that core and formed the surrounding ring. Star formation continues in remnant dark clouds distant from the original core. The local initial mass functions differ significantly across the region, although the global IMF is field-like. Interestingly, the lack of Hα emission in stars near λ Ori indicates that the environment of the massive stars was not conducive for the survival of accretion disks.

The L1617 and L1622 Cometary Clouds in Orion

Bo Reipurth[1], S.T. Megeath[2], John Bally[3], and J. Walawender[1]

[1] Institute for Astronomy, University of Hawaii, 640 N. Aohoku Place, Hilo, HI 96720, USA
[2] Ritter Observatory, M.S. 113, Department of Physics and Astronomy, University of Toledo, Toledo, OH 43606-3390, USA
[3] Center for Astrophysics and Space Astronomy, University of Colorado, Boulder, CO 80389, USA

E-mail contact: reipurth *at* ifa.hawaii.edu

The molecular cloud complex encompassing the cometary clouds L1617 and L1622 is located just outside of Barnard's Loop in Orion. It lies to the northeast of the Orion Nebula Cluster at a projected distance of 60 pc. The two clouds have radial velocities that differ by about 10 km/s, suggesting that they are not physically associated. Both clouds show evidence for recent, limited low-mass star formation. In L1617 one finds the two Class I sources responsible for the HH 111 giant jet complex and for the HH 110 flow, which may have resulted from a flow being deflected by a cloud. L1622 harbors at least 30 young stellar objects, including 8 protostars, many of which have only recently been identified by Spitzer Space Telescope observations.

Orion Outlying Clouds

Juan M. Alcalá[1], Elvira Covino[1], and Silvio Leccia[1]

[1] INAF- Osservatorio Astronomico di Capodimonte, Via Moiariello 16, 80131, Naples, Italy

E-mail contact: jmae *at* sun1.na.astro.it

In this chapter we review the properties of the Orion outlying clouds at $b < -21°$. These clouds are located far off the Orion giant molecular cloud complex and are in most cases small cometary-shaped clouds, with their head pointing back towards the main Orion clouds. A wealth of data indicate that star formation is ongoing in many of these clouds. The star formation in these regions might have been triggered due to the strong impact of the massive stars in the Orion OB association. Some of the clouds discussed here may be part of the Orion-Eridanus bubble. An overview on each individual cloud is given. A synthesis of the Pre-Main Sequence stars discovered in these clouds is presented. We also discuss the millimeter and centimeter data and present a review of the outflows and Herbig-Haro objects so far discovered in these clouds.

The Dispersed Young Population in Orion

César Briceño[1]

[1] Centro de Investigaciones de Astronomía (CIDA), Apartado Postal 264, Mérida 5101-A, Venezuela

E-mail contact: briceno *at* cida.ve

The Orion OB1 Association, at a distance of roughly 400 pc and spanning over 200 $\deg^2$ on the sky, is one of the largest and nearest OB associations. With a wide range of ages and environmental conditions, Orion is an ideal laboratory for investigating fundamental questions related to the birth of stars and planetary systems. This rich region exhibits all stages of the star formation process, from very young, embedded clusters, to older, fully exposed young stars; it also harbors dense clusters and widely spread populations in vast, low stellar density areas. This review focuses on the later, namely, the low-mass ($M_*\lesssim 2$ $M_\odot$), pre-main sequence population spread over wide spatial scales in Orion OB1, mostly in the off-cloud areas. As ongoing studies yield more complete censa it becomes clearer that this "distributed" or non-clustered population, is as numerous as that located in the molecular clouds; modern studies of star formation in Orion would be incomplete if they did not include this widely spread population.

Star Formation and Molecular Clouds towards the Galactic Anti-Center

Bo Reipurth[1] and Chi-Hung Yan[2,3]

[1] Institute for Astronomy, University of Hawaii, 640 N. Aohoku Place, Hilo, HI 96720, USA
[2] Institute of Astronomy and Astrophysics, Academia Sinica, P.O. Box 23-141, Taipei 10617, Taiwan
[3] National Taiwan Normal University, 88 Sec. 4, Tingzhou Road, Taipei, 11766, Taiwan

E-mail contact: reipurth *at* ifa.hawaii.edu

The Galactic Anticenter region hosts a a number of massive molecular cloud complexes, some of which are currently actively forming stars. Two major OB associations, Gem OB1 and Aur OB1 are found in this direction, each with numerous massive stars and a supernova remnant. The dominant region of star formation is centered around the Sh 2-235 complex and the nearby star forming regions at AFGL 5142, 5144, and 5157 towards Aur OB1. Studies of these regions have long been affected by relatively poor distance determinations, although there is general consensus that most regions are located at distances between 1.5 and 2 kpc. A number of well-known, relatively isolated Herbig Ae/Be stars are found in this general direction, including RR Tau, HD 250550, and LkHα 208.

The Monoceros R2 Molecular Cloud

John M. Carpenter[1] **and Klaus W. Hodapp**[2]

[1] California Institute of Technology, Pasadena, CA 91125, USA
[2] Institute for Astronomy, University of Hawaii, Hilo, HI 96720, USA

E-mail contact: jmc *at* astro.caltech.edu

The Monoceros R2 region was first recognized as a chain of reflection nebulae illuminated by A- and B-type stars. These nebulae are associated with a giant molecular cloud that is one of the closest massive star forming regions to the Sun. This chapter reviews the properties of the Mon R2 region, including the namesake reflection nebulae, the large scale molecular cloud, global star formation activity, and properties of prominent star forming regions in the cloud.

Star Formation in the Rosette Complex

Carlos G. Román-Zúñiga[1] **and Elizabeth A. Lada**[2]

[1] Centro Astronómico Hispano Alemán, Jesús Durbán Remón 2-2, Almería 04004, Spain
[2] Astronomy Department, University of Florida, 211 Bryant Space Sciences Center, Gainesville, FL 32611, USA

E-mail contact: croman *at* caha.es

The Rosette Complex in the Constellation of Monoceros is a magnificent laboratory for the study of star formation. The region presents an interesting scenario, in which an expanding HII region generated by the large OB association NGC 2244 is interacting with a giant molecular cloud. Inside the cloud a number of stellar clusters have formed recently. In this chapter we present a review of past and present research on the region, and discuss investigations relevant to the physics of the nebula and the molecular cloud. We also review recent work on the younger embedded clusters and individual nebulous objects located across this important star forming region.

The Young Cluster and Star Forming Region NGC 2264

S.E. Dahm[1]

[1] Department of Astronomy, California Institute of Technology, MS 105-24, Pasadena, CA 91125, USA

E-mail contact: sdahm *at* keck.hawaii.edu

NGC 2264 is a young Galactic cluster and the dominant component of the Mon OB1 association lying approximately 760 pc distant within the local spiral arm. The cluster is hierarchically structured, with subclusters of suspected members spread across several parsecs. Associated with the cluster is an extensive molecular cloud complex spanning more than two degrees on the sky. The combined mass of the remaining molecular cloud cores upon which the cluster is superposed is estimated to be at least $\sim 3.7 \times 10^4$ $M_\odot$. Star formation is ongoing within the region as evidenced by the presence of numerous embedded clusters of protostars, molecular outflows, and Herbig-Haro objects. The stellar population of NGC 2264 is dominated by the O7 V multiple star, S Mon, and several dozen B-type zero-age main sequence stars. X-ray imaging surveys, Hα emission surveys, and photometric variability studies have identified more than 600 intermediate and low-mass members distributed throughout the molecular cloud complex, but concentrated within two densely populated areas between S Mon and the Cone Nebula. Estimates for the total stellar population of the cluster range as high as 1000 members and limited deep photometric surveys have identified $\sim$230 substellar mass candidates. The median age of NGC 2264 is estimated to be $\sim$3 Myr by fitting various pre-main sequence isochrones to the low-mass stellar population, but an apparent age dispersion of at least $\sim$5 Myr can be inferred from the broadened sequence of suspected members. Infrared and millimeter observations of the cluster have identified two prominent sites of star formation activity centered near NGC 2264 IRS1, a deeply embedded early-type (B2–B5) star, and IRS2, a star forming core and associated protostellar cluster. NGC 2264 and its associated molecular clouds have been extensively examined at all wavelengths, from the centimeter regime to X-rays. Given its relative proximity, well-defined stellar population, and low foreground extinction, the cluster will remain a prime candidate for star formation studies throughout the foreseeable future.

The Canis Major Star Forming Region

Jane Gregorio-Hetem[1]

[1] Universidade de São Paulo, Rua do Matão, 1226 - IAG/USP, 05508-900, São Paulo- SP, Brazil

E-mail contact: jane *at* astro.iag.usp.br

The shape of the main arc formed by the Canis Major clouds has been suggested to result from a supernova explosion possibly triggering the recent star formation activity. The presence of dozens of OB stars and reflection nebulae forms the CMa OB1/R1 associations. More than a hundred emission line stars are found in this region, including the famous Z CMa, a binary system containing a Herbig Be star and a FUor companion. Several embedded infrared clusters with different ages are associated with the CMa clouds. The main characteristics of the region in terms of cloud structure, stellar content, age of associated young clusters, distance, and X-ray emission are presented in this chapter. Some of the arguments in favor and against the hypothesis of induced star formation are discussed in the last section.

NGC 2362: The Terminus of Star Formation

S.E. Dahm[1]

[1] Department of Astronomy, California Institute of Technology, MS 105-24, Pasadena, CA 91125, USA

E-mail contact: sdahm *at* keck.hawaii.edu

NGC 2362 is a richly populated Galactic cluster, devoid of natal molecular gas and dust. The cluster represents the final product of the star forming process and hosts an unobscured and near-complete initial mass function. NGC 2362 is dominated by the O9 Ib multiple star, τ CMa, as well as several dozen unevolved B-type stars. Distributed throughout the cluster are several hundred suspected intermediate and low-mass pre-main sequence members. Various post-main sequence evolutionary models have been used to infer an age of $\sim$5 Myr for the one evolved member, τ CMa. These estimates are in close agreement with the ages derived by fitting pre-main sequence isochrones to the contracting, low-mass stellar population of the cluster. The extremely narrow sequence of stars, which extends more than 9 mag in the optical color-magnitude diagram, suggests that star formation within the cluster occurred rapidly and coevally across the full mass spectrum. Ground-based near infrared and Hα emission surveys of NGC 2362 concluded that most ($\sim$90%) of the low-mass members have already dissipated their optically-thick, inner ($\ll$1 AU) circumstellar disks. *Spitzer* IRAC observations of the cluster have confirmed these results, placing an upper limit on the primordial, optically thick disk fraction of the cluster at $\sim$7$\pm$2%. The presence of circumstellar disks among candidate members of NGC 2362 is also strongly mass-dependent, such that no stars more massive than $\sim$1.2 $M_\odot$ exhibit significant infrared excess shortward of 8 μm. NGC 2362 will likely remain a favored target of ground-based and space-based observations. Its well-defined upper main sequence, large population of low-mass, pre-main sequence stars, and the narrow age spread evident in the color-magnitude diagram ensure its role as a standard model of cluster as well as stellar evolution.

Young Stars and Dust Clouds in Puppis and Vela

Bertil Pettersson[1]

[1] Dept. of Physics and Astronomy, Astronomy and Space Physics, Box 515, SE-751 20 Uppsala, Sweden

E-mail contact: Bertil.Pettersson *at* astro.uu.se

This chapter deals with star formation inside of $\sim$2.5 kpc from the Sun, mainly in the constellations of Vela and Puppis in the Galactic longitude interval 240deg $< l <$ 280 deg and the latitude interval -20 deg $< b <$ 6 deg. Star formation in this region is dominated by the Vela Molecular Ridge, a large molecular complex seen against the background Carina spiral arm, and by the cometary globules and other molecular clouds in the Gum Nebula, a large nearby H II-region. The IRAS Vela Shell and its relation to the Gum Nebula is briefly discussed. A large number of surveys at many different wavelengths exist, but the treatment here concentrates on the numerous works more directly aimed at this particular/specific region. Some particular regions that have received much attention are the Vela Molecular

Ridge where a large number of deeply embedded young clusters and protostars have been found, as well as signs of a progressive star formation going from W to E along the Ridge, and some of the Cometary Globules, in particular CG 30 with its outflows from multiple sources in the dense head, and ESO 210-6A with the well-known system of Herbig-Haro flows HH 46 and 47.

The Embedded Massive Star Forming Region RCW 38

Scott J. Wolk[1], **Tyler L. Bourke**[1], **and Miquela Vigil**[2]

[1] Harvard–Smithsonian Center for Astrophysics, Cambridge MA 02138, USA
[2] Lincoln Laboratory, Massachusetts Institute of Technology, Lexington MA 02420, USA

E-mail contact: swolk *at* cfa.harvard.edu

RCW 38 is a uniquely young (<1 Myr), embedded ($A_V \sim 10$) stellar cluster surrounding a pair of early O stars (∼O5.5) and is one of the few regions within 2 kpc other than Orion to contain over 1000 members. X-ray and deep near-infrared observations reveal a dense cluster with over 200 X-ray sources and 400 infrared sources embedded in a diffuse hot plasma within a 1 pc diameter. The central O star has evacuated its immediate surroundings of dust, creating a wind bubble ∼0.1 pc in radius that is confined by the surrounding molecular cloud, as traced by millimeter continuum and molecular line emission. The interface between the bubble and cloud is a region of warm dust and ionized gas, which shows evidence for ongoing star formation. Extended warm dust is found throughout a 2–3 pc region and coincides with extended X-ray plasma. This is evidence that the influence of the massive stars reaches beyond the confines of the O star bubble. RCW 38 appears similar in structure to RCW 49 and M 20 but is at an earlier evolutionary phase. RCW 38 appears to be a blister compact HII region lying just inside the edge of a giant molecular cloud.

The Carina Nebula: A Laboratory for Feedback and Triggered Star Formation

Nathan Smith[1] **and Kate J. Brooks**[2]

[1] Astronomy Department, University of California, 601 Campbell Hall, Berkeley, CA 94720, USA
[2] ATNF, P.O. Box 76, Epping NSW 1710, Australia

E-mail contact: nathans *at* astro.berkeley.edu

The Carina Nebula (NGC 3372) is our richest nearby laboratory in which to study feedback through UV radiation and stellar winds from very massive stars during the formation of an OB association, at an early phase before supernova explosions have disrupted the environment. This feedback is triggering new generations of star formation around the periphery of the nebula, while simultaneously evaporating the gas and dust reservoirs out of which young stars are trying to accrete. Carina is currently powered by UV radiation from 65 O-type stars and 3 WNH stars, but for most of its lifetime when its most massive star (η Carinae) was on the main-sequence, the Carina Nebula was powered by 70 O-type stars that produced a hydrogen ionizing luminosity 150 times stronger than in the Orion Nebula. At a distance of 2.3 kpc, Carina has the most extreme stellar population within a few kpc of the Sun, and suffers little interstellar extinction. It is our best bridge between the detailed star-formation processes that can be studied in nearby regions like Orion, and much more extreme but also more distant regions like 30 Doradus. Existing observations have only begun to tap the tremendous potential of this region for understanding the importance of feedback in star formation — it will provide a reservoir of new discoveries for the next generation of large ground-based telescopes, space telescopes, and large submillimeter and radio arrays.

Chamaeleon

Kevin L. Luhman[1]

[1] Department of Astronomy and Astrophysics, The Pennsylvania State University, University Park, PA 16802, USA

E-mail contact: kluhman *at* astro.psu.edu

The dark clouds in the constellation of Chamaeleon have distances of 160-180 pc from the Sun and a total mass of $\sim$5000 $M_\odot$. The three main clouds, Cha I, II, and III, have angular sizes of a few square degrees and maximum extinctions of $A_V \sim$ 5-10. Most of the star formation in these clouds is occurring in Cha I, with the remainder in

Cha II. The current census of Cha I contains 237 known members, 33 of which have spectral types indicative of brown dwarfs (>M6). Approximately 50 members of Cha II have been identified, including a few brown dwarfs. When interpreted with the evolutionary models of Chabrier and Baraffe, the H-R diagram for Cha I exhibits a median age of $\sim$2 Myr, making it coeval with IC 348 and slightly older than Taurus ($\sim$1 Myr). The IMF of Cha I reaches a maximum at a mass of 0.1-0.15 $M_\odot$, and thus closely resembles the IMFs in IC 348 and the Orion Nebula Cluster. The disk fraction in Cha I is roughly constant at $\sim 50\%$ from 0.01 to 0.3 $M_\odot$ and increases to $\sim 65\%$ at higher masses. In comparison, IC 348 has a similar disk fraction at low masses but a much lower disk fraction at $M \gtrsim 1\ M_\odot$, indicating that solar-type stars have longer disk lifetimes in Cha I.

Young Stars and Molecular Clouds in the IC 2944/2948 Complex

Bo Reipurth[1]

[1] Institute for Astronomy, University of Hawaii, 640 N. Aohoku Place, Hilo, HI 96720, USA

E-mail contact: reipurth *at* ifa.hawaii.edu

One of the fine clusters of the southern sky is found within the extended HII region IC 2944/2948. The cluster, which appears to be only a few million years old, contains a dozen O stars, many of which are binaries, and is surrounded by a shell of remnant molecular clouds containing embedded IRAS sources. At a distance of about 2 kpc, only a few of the faint cluster members have been identified so far. The region contains a remarkable group of small globules silhouetted against the luminous gas around the OB stars and known as Thackeray's globules.

The Southern Coalsack

Lars-Aake Nyman[1]

[1] European Southern Observatory, Casilla 19001, Santiago 19, Chile

E-mail contact: lnyman *at* eso.org

The Southern Coalsack is the most prominent, isolated dark cloud in the southern Milky Way. It is situated on the Galactic equator at $l = 303\,\mathrm{deg}$ and has a diameter of about 6^o. The visual extinction over the cloud varies by between 1 and 3 magnitudes but can be much higher in small condensations and globules. From photometric studies the distance to the Coalsack has been estimated to ~ 150 pc. A CO (1–0) survey of the whole cloud showed that it is very fragmented, consisting of clumps and filaments, and the total mass is estimated to $\sim 3500 M_\odot$. A cloud of this size and mass would be expected to contain young stars, but so far none has been found, although searches have been made for T Tauri stars, flare stars, HH objects, and IRAS point sources with color-color characteristics of young stars. The Coalsack may not be forming stars because it contains an unusually small amount of dense gas compared to typical star-forming clouds, as indicated by a ^{13}CO survey, or it is a young molecular cloud complex, implied by the fact that the densest globule is not centrally condensed, which is normally the case for globules and star-forming cores.

The Nearest OB Association: Scorpius-Centaurus (Sco OB2)

Thomas Preibisch[1] **and Eric Mamajek**[2]

[1] Universitäts-Sternwarte München, Scheinerstr. 1, D-81679 München, Germany
[2] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, MS-42, Cambridge, MA 02138, USA

E-mail contact: preibisch *at* usm.uni-muenchen.de

We summarize observational results on the stellar population and star formation history of the Scorpius-Centaurus OB Association (Sco OB2), the nearest region of recent massive star formation. It consists of three subgroups, Upper Scorpius (US), Upper Centaurus-Lupus (UCL), and Lower Centaurus-Crux (LCC) which have ages of about 5, 17, and 16 Myr. While the high- and intermediate mass association members have been studied for several decades, the low-mass population remained mainly unexplored until rather recently.

In Upper Scorpius, numerous studies, in particular large multi-object spectroscopic surveys, have recently revealed hundreds of low-mass association members, including dozens of brown dwarfs. The investigation of a large representative sample of association members provided detailed information about the stellar population and the star formation

history. The empirical mass function could be established over the full stellar mass range from $0.1\,M_\odot$ up to $20\,M_\odot$, and was found to be consistent with recent determinations of the field initial mass function. A narrow range of ages around 5 Myr was found for the low-mass stars, the same age as had previously (and independently) been derived for the high-mass members. This supports earlier indications that the star formation process in US was triggered, and agrees with previous conjectures that the triggering event was a supernova- and wind-driven shock-wave originating from the nearby UCL group.

In the older UCL and LCC regions, large numbers of low-mass members have recently been identified among X-ray and proper-motion selected candidates. In both subgroups, low-mass members have also been serendipitously discovered through investigations of X-ray sources in the vicinity of better known regions (primarily the Lupus and TW Hya associations). While both subgroups appear to have mean ages of $\sim$16 Myr, they both show signs of having substructure. Their star-formation histories may be more complex than that of the younger, more compact US group.

Sco-Cen is an important "astrophysics laboratory" for detailed studies of recently formed stars. For example, the ages of the sub-groups of 5 Myr and $\sim$ 16 Myr are ideal for studying how circumstellar disks evolve. While no more than a few percent of the Sco-Cen members appear to be accreting from a circumstellar disk, recent *Spitzer* results suggest that at least $\sim$35% still have cold, dusty, debris disks.

The Circinus Star Forming Complex

Bo Reipurth[1], John Bally[2] and Josh Walawender[1]

[1] Institute for Astronomy, University of Hawaii, 640 N. Aohoku Place, Hilo, HI 96720, USA
[2] CASA, University of Colorado, Boulder, CO 80309, USA

E-mail contact: reipurth *at* ifa.hawaii.edu

The Circinus giant molecular cloud is a little explored region that deserves closer study owing to the many signs of vigorous low-mass star formation in the form of Hα emission stars, Herbig-Haro objects, molecular outflows, and embedded sources. The western part of the cloud complex has a filamentary structure with numerous cavities, indicating the effect of powerful molecular outflows. It is likely that the current strong star formation activity was triggered by a supernova explosion. Our present limited knowledge about this region is summarized, and several particularly interesting sources are discussed.

The Lupus Clouds

Fernando Comerón[1]

[1] European Southern Observatory, Karl-Schwarzschild-Str. 2, D-85737 Garching bei München, Germany

E-mail contact: fcomeron *at* eso.org

The Lupus clouds compose one of the main low-mass star forming complexes within 200 pc of the Sun. They contain four main star forming sites, including the rich T Tauri association in Lupus 3. They are located in the Scorpius-Centaurus OB association, whose massive stars are likely to have played a significant role in the evolution and perhaps the origin of the complex. The entire variety of objects related to the various stages of early stellar evolution are represented in Lupus, including some of the best studied T Tauri stars like RU Lup. The determination of many properties of the clouds, as well as their associated stellar population, are limited by the uncertainty with which the distance is known. We argue that a single value of the distance is probably inadequate to be representative of the entire complex, and that depth effects are likely to be significant, as expected from its large extent on the plane of the sky. The total mass of molecular gas in the complex is a few times 10^4 M$_\odot$. The most distinctive property of its stellar population is the outstanding abundance of mid M-type pre-main sequence stars. Some likely substellar objects have been identified as well, particularly thanks to mid-infrared observations carried out with the Spitzer Space Observatory. A widely distributed young low-mass population of weak-line T Tauri stars, identified by its X-ray emission, is observed in the direction of Lupus but it is probably related to the Gould Belt rather than to the star forming complex. A few individual objects of particular interest are briefly reviewed: the Herbig Ae/Be stars HR 5999 and HR 6000 that dominate the Lupus 3 cloud, the classical T Tauri star RU Lup, the EXor class prototype EX Lup, the very low luminosity, outflow-driving sources HH 55 and Par-Lup3-4, the extreme emission-line star Th 28, and the binary object GQ Lup composed of an ordinary T Tauri star with a substellar companion of possible planetary mass.

Star Formation in the ρ Ophiuchi Molecular Cloud

Bruce A. Wilking[1], **Marc Gagné**[2], **and Lori E. Allen**[3]

[1] Department of Physics and Astronomy, University of Missouri-St. Louis, 1 University Boulevard, St. Louis, MO 63121, USA
[2] Department of Geology and Astronomy, West Chester University, West Chester, PA 19383, USA
[3] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, MS42, Cambridge, MA 02138, USA

E-mail contact: bwilking *at* umsl.edu

A review of star formation in the Rho Ophiuchi molecular complex is presented, with particular emphasis on studies of the main cloud, L1688, since 1991. Recent photometric and parallax measurements of stars in the Upper Scorpius subgroup of the Sco-Cen OB association suggest a distance for the cloud between 120 and 140 parsecs. Star formation is ongoing in the dense cores of L1688 with a median age for young stellar objects of 0.3 Myr. The surface population appears to have a median age of 2-5 Myr and merges with low mass stars in the Upper Scorpius subgroup. Making use of the most recent X-ray and infrared photometric surveys and spectroscopic surveys of L1688, we compile a list of over 300 association members with counterparts in the 2MASS catalog. Membership criteria, such as lithium absorption, X-ray emission, and infrared excess, cover the full range of evolutionary states for young stellar objects. Spectral energy distributions are classified for many association members using infrared photometry obtained from the *Spitzer Space Telescope*.

Low Mass Star Formation in the Norma Cloud

Bo Reipurth[1] **and Markus Nielbock**[2]

[1] Institute for Astronomy, University of Hawaii, 640 N. Aohoku Place, Hilo, HI 96720, USA
[2] Max-Planck-Institut für Astronomie, Königstuhl 17, D-69118 Heidelberg, Germany

E-mail contact: reipurth *at* ifa.hawaii.edu

A small filamentary cloud in Norma hosts a number of young low-mass stars in various stages of evolution, from visible Hα emission stars to embedded sources detected only in the sub-millimeter regime. The best known source is V346 Nor, an FU Orionis star that brightened in the early 1980s. The morphology of the cloud complex and an apparent age gradient along the cloud suggests that star formation in this region was triggered by an external event.

The Ara OB 1a Association

Scott J. Wolk[1], **Fernando Comerón**[2], **and Tyler Bourke**[3]

[1] Harvard–Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138; USA
[2] European Southern Observatory,Karl-Schwarzschild-Strasse 2, 85748 Garching, Germany
[3] Harvard–Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138; USA

E-mail contact: swolk *at* cfa.harvard.edu

The Ara OB1a association is one of the closest sites where triggered star formation is visible for multiple generations of massive stars. At about 1.3 kpc distance, it contains complex environments including cleared young clusters, embedded infrared clusters, CO clouds with no evidence of star formation, and clouds with evidence of ongoing star formation. In this review we discuss the research on this region spanning the last half-century. It has been proposed that the current configuration is the result of an expanding wave of neutral gas set in motion between 10–40 million years ago in combination with photoionization from the current epoch.

Young Stars in NGC 6231 and the Sco OB1 Association

Bo Reipurth[1]

[1] Institute for Astronomy, University of Hawaii, 640 N. Aohoku Place, Hilo, HI 96720, USA

E-mail contact: reipurth *at* ifa.hawaii.edu

NGC 6231 is a young cluster in the southern sky, around 3-5 Myr old, located at a distance of about 1.6 kpc at the

near side of the Sagittarius spiral arm. It forms the nucleus of the extended Sco OB1 association. The cluster is very rich, with more than 100 massive stars, among them 15 O-stars. Radial velocity studies have revealed a very large binary fraction among these OB stars. The young low-mass population has recently been identified using deep X-ray observations. Within the large HII region IC 4678 that surrounds NGC 6231 there exists a major elephant trunk, which shows evidence for recent second-generation star formation in the form of young B-stars surrounded by reflection nebulae and a number of low-mass Hα emission stars.

The Pipe Nebula: A Young Molecular Cloud Complex

João Alves[1], **Marco Lombardi**[2], **and Charles J. Lada**[3]

[1] Calar Alto Observatory – Centro Astronómico Hispano Alemán, C/Jesús Durbán Remón 2-2, 04004 Almeria, Spain
[2] European Southern Observatory, Karl-Schwarzschild-Str. 2, 85748 Garching, Germany, and University of Milan, Department of Physics, via Celoria 16, I-20133 Milan, Italy
[3] Harvard-Smithsonian Center for Astrophysics, Mail Stop 72, 60 Garden Street, Cambridge, MA 02138, USA

E-mail contact: jalves *at* caha.es

The Pipe Nebula is among the closest molecular clouds to Earth, and one of the few observable with the naked eye. The entire complex has a mass of about 10^4 M$_\odot$ and lies at a distance of about 130 pc in the direction of the Galactic center. Only Barnard 59, at the northwestern edge of the complex, is currently known to be forming stars and is associated with several T Tauri stars and deeply embedded YSOs. Although an ideal target for star formation studies, the Pipe Nebula remains until this day a poorly studied complex.

RCW 120: A Perfect Bubble

Lise Deharveng[1] **and Annie Zavagno**[1]

[1] LAM, 2 Place Le Verrier, 13248 Marseille Cedex 4, France

E-mail contact: lise.deharveng *at* oamp.fr

RCW 120 is a small inconspicuous optical H II region. It is also the archetype of the many bubbles discovered by the Spitzer Space Telescope. What can we learn about star formation in such a simple object? We discuss the distribution of the associated dust material. A layer of neutral material has been collected around the ionized gas during the expansion of the H II region. Many young stellar objects are observed on the border of RCW 120. We discuss their evolutionary states, masses and locations with respect to the cold dust condensations. Different processes of triggered star formation are at work in the collected layer, forming stars of all masses.

The Isolated Embedded Cluster GM 24

Mauricio Tapia[1] **and Paolo Persi**[2]

[1] Instituto de Astronomía, Universidad Nacional Autónoma de México, Ensenada, Apartado Postal 877, 22830 Ensenada, B.C., Mexico
[2] INAF-Istituto Astrofisica Spaziale e Fisica Cosmica Roma, Via Fosso del Cavaliere 100, 00133 Roma, Italy

E-mail contact: mt *at* astrosen.unam.mx

GM 24 is a compact nebulous object immersed in the low-brightness HII region RCW 126. It is associated with a warm and dense CO cloud at whose centre a deeply embedded ($A_V = 55$) massive cluster of more than one hundred members was found. The most luminous young stellar object of the cluster, Irs 3 (= IRAS 17136−3617), radiates most of its energy in the mid- and far-infrared and ionizes a compact HII region. The kinematic distance, derived from the radial velocities of CO and hydrogen recombination lines, is $d = 2.0$ kpc. The physical properties of the complex, derived from the available observations, are presented.

Star Formation in NGC 6334

Paolo Persi[1] **and Mauricio Tapia**[2]

[1] INAF-Istituto Astrofisica Spaziale e Fisica Cosmica Roma, Via Fosso del Cavaliere 100, 00133 Roma, Italy

[2] Instituto de Astronomía, Universidad Nacional Autónoma de México, Ensenada, Apartado Postal 877, 22830 Ensenada, B.C., Mexico

E-mail contact: paolo.persi *at* iasf-roma.inaf.it

The bright nebula NGC 6334 extends nearly 0.4 square degrees across the sky and is located at a distance from the Sun of 1.61 kpc. This region contains some of the most active sites of massive star formation in our Galaxy. Discovered by their bright far-infrared emission associated with radio continuum peaks, these nuclei of activity are aligned along a dense molecular ridge that runs parallel to the Galactic Plane and stretches some 10 pc. It has a total mass of a few 10^5 $M_\odot$. The physical characteristics of the active spots range widely, from well developed expanding HII regions to deeply embedded, still contracting, young objects detected only as millimeter sources, thus at their earliest observable stage of their evolution. The oldest optically visible round HII regions with central O-type stars are found in the southern parts. There is no clear spatial evolutionary correletion across the region. In this review we describe the observed characteristics of the giant molecular cloud complex and present detailed discussions on the individual centres of star formation.

The multiwavelength picture of star formation in the very young open cluster NGC 6383

Gregor Rauw[1] and Michaël De Becker[1]

[1] Institut d'Astrophysique et de Géophysique, Université de Liège, Allée du 6 Août 17, Bât B5c, B-4000 Liège, Belgium

E-mail contact: rauw *at* astro.ulg.ac.be

We review the properties of the very young (~ 2 Myr) open cluster NGC 6383. The cluster is dominated by the massive binary HD 159176 (O7 V + O7 V). The distance to NGC 6383 is consistently found to be 1.3 ± 0.1 kpc and the average reddening is determined to be $E(B-V) = 0.32 \pm 0.02$. Several pre-main sequence candidates have been identified using different criteria relying on the detection of emission lines, infrared excesses, photometric variability and X-ray emission.

M20: Star Formation in a Young HII Region

Jeonghee Rho[1], Bertrand Lefloch[2], William T. Reach[1] and José Cernicharo[3]

[1] Spitzer Science Center, California Institute of Technology, Pasadena, CA 91125, USA
[2] Laboratoire d'Astrophysique, Observatoire de Grenoble, BP 53, F-38041, Grenoble CEDEX9, France
[3] DAMIR, CISC, C./Serrano, 121, 28006 Madrid, Spain

E-mail contact: rho *at* ipac.caltech.edu

The Trifid Nebula (M20) has a remarkable optical appearance with a large, reddish nebula of gas ionized by an O7 star (HD 164492) and trisected by obscuring dust lanes, with a blue reflection nebula in the north. During the last two decades, M20 has generated considerable interest because of multi-wavelength identifications of sites of low- and high-mass star formation. M20 is a young HII region showing active, dynamic "pre-Orion" star formation, containing massive, young stars undergoing collapse and violent mass ejection, as well as a dense population of protostars and more developed pre-main sequence stars. Different stages of star formation have been detected at various wavelengths, as well as optical jets, mid- and far-infrared protostars, near-infrared young stellar objects, Hα emission stars, X-ray sources, and OH masers. M20 is relatively close, at a distance of 1.67 kpc with a low line-of-sight extinction (A_v=1.3 mag), and it is compact, with a small diameter of only 3.5 pc. M20 is an isolated HII region with a single O star, which provides an ideal place to investigate the onset of star birth and triggered star formation. We review the highlights of studies of star forming activities in the Trifid Nebula.

The Lagoon Nebula and its Vicinity

N.F. Tothill[1,2], Marc Gagné[3], B. Stecklum[4], and M.A. Kenworthy[5]

[1] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA
[2] School of Physics, University of Exeter, Stocker Road, Exeter, EX4 4QL, UK
[3] Department of Geology and Astronomy, West Chester University, West Chester, PA 19383, USA
[4] Thüringer Landessternwarte Tautenburg, Sternwarte 5, D-07778 Tautenburg, Germany

[5] Steward Observatory, University of Arizona, 933 N. Cherry Avenue, Tucson, AZ 85721, USA

E-mail contact: ntothill *at* cfa.harvard.edu

The Lagoon Nebula is an HII region in the Sagittarius Arm, about 1.3 kpc away, associated with the young (1–3 Myr) open cluster NGC 6530, which contains several O stars and several dozen B stars. Lower-mass cluster members, detected by X-ray and Hα emission, and by near-IR excess, number more than a thousand. Myr-old star formation is traced by the optically-visible HII region and cluster; observations of infrared and submillimetre-wave emission, and of optical emission features, indicate ongoing star formation in several locations across the Lagoon. The most prominent of these are the Hourglass Nebula and M8 E. Submillimetre-wave observations also reveal many clumps of dense molecular gas, which may form the next generation of stars. The complex structure of the region has been shaped by the interaction of the underlying molecular gas with multiple massive stars and episodes of star formation. NGC 6530 is the oldest component, with the newest stars found embedded in the molecular gas behind the cluster and at its southern rim. A degree to the east of the Lagoon, Simeis 188 is a complex of emission and reflection nebulae, including the bright-rimmed cloud NGC 6559; the presence of Hα emission stars suggests ongoing star formation.

Star Formation in Sagittarius: The Lynds 291 Cloud

Bo Reipurth[1], Steven A. Rodney[2], and Steve Heathcote[3]

[1] Institute for Astronomy, University of Hawaii, 640 N. Aohoku Place, Hilo, HI 96720, USA
[2] Institute for Astronomy, University of Hawaii, 2680 Woodlawn Drive, Honolulu, HI 96822, USA
[3] SOAR, Casilla 603, La Serena, Chile

E-mail contact: reipurth *at* ifa.hawaii.edu

The Lynds 291 cloud in Sagittarius is a giant molecular cloud with approximate dimensions 20 pc $\times$ 80 pc located at a distance of approximately 1700 pc. The northern part of the cloud is dominated by the HII region IC 1284 and the two reflection nebulae NGC 6589 and NGC 6595. The southwestern edge of the cloud consists of a dense ridge with numerous dense cores which is being compressed by an expanding HI bubble energized by OB stars and possibly several past supernova explosions. Star formation is taking place all along the ridge. A particularly well studied source is IRAS 18162–2048, which drives the very luminous Herbig-Haro objects HH 80/81, a highly collimated radio continuum jet, and a massive molecular outflow.

The Young Cluster NGC 6604 and the Serpens OB2 Association

Bo Reipurth[1]

[1] Institute for Astronomy, University of Hawaii, 640 N. Aohoku Place, Hilo, HI 96720, USA

E-mail contact: reipurth *at* ifa.hawaii.edu

NGC 6604 is a young cluster in Serpens with an age of 4-5 Myr and at a distance of about 1.7 kpc. It forms the densest part of the wider Ser OB2 association, which contains about 100 OB stars. NGC 6604 lies about 65 pc above the Galactic plane, and has attracted special interest since it has produced a thermal chimney stretching 200 pc out of the plane. The combined effect of winds and radiation from the many OB stars has produced a rim of dense molecular material in which second-generation star formation is currently taking place.

Star Formation in the Eagle Nebula

Joana M. Oliveira[1]

[1] School of Physical and Geographical Sciences, Lennard-Jones Laboratories, Keele University, Staffordshire ST5 5BG, UK

E-mail contact: joana *at* astro.keele.ac.uk

M16 (the Eagle Nebula) is a striking star forming region, with a complex morphology of gas and dust sculpted by the massive stars in NGC 6611. Detailed studies of the famous "elephant trunks" dramatically increased our understanding of the massive star feedback into the parent molecular cloud. A rich young stellar population (2−3 Myr) has been identified, from massive O-stars down to substellar masses. Deep into the remnant molecular material, embedded

protostars, Herbig-Haro objects and maser sources bear evidence of ongoing star formation in the nebula, possibly triggered by the massive cluster members. M 16 is a excellent template for the study of star formation under the hostile environment created by massive O-stars. This review aims at providing an observational overview not only of the young stellar population but also of the gas remnant of the star formation process.

Star formation in M17

Rolf Chini[1] **and Vera Hoffmeister**[1]

[1] Astronomisches Institut, Ruhr-Universität Bochum, 44780 Bochum, Germany

E-mail contact: rolf.chini *at* gmx.de

M17 is a region of active high-mass star formation at a distance of 2.1 kpc. It consists of a luminous HII region, a huge adjacent molecular cloud and an embedded young cluster with an age of about 5×10^5 years. Spectroscopic investigations suggest that stars later than about B8 have not yet reached the main sequence. In its center two O4 and several later O-type stars seem to have triggered the formation of further young objects at the interface between the HII region and the surrounding molecular cloud. Altogether, there are several thousand infrared stars within a projected area of 3.6×3.7 pc. The local extinction law is characterized by a ratio of total-to-selective extinction of $R = 3.9$. About 74% of the investigated cluster members show infrared excess suggesting the presence of dense circumstellar material; the excess frequency is higher for fainter stars. CO band-head features indicate that accretion is still going on in a large number of objects. Nearly a thousand sources in the field are known to exhibit X-ray emission. The spatial distribution of infrared excess sources is suggestive of triggered star formation with the youngest objects populating the outer cluster regions. Spatially resolved images of circumstellar disks and shells have been obtained for a number of high-mass sources, suggesting the accretion scenario to work also in the high-mass regime.

The W40 Cloud Complex

Steven A. Rodney[1] **and Bo Reipurth**[2]

[1] Institute for Astronomy, University of Hawaii, 2680 Woodlawn Dr., Honolulu, HI 96822, USA
[2] Institute for Astronomy, University of Hawaii, 640 N. Aohoku Place, Hilo, HI 96720, USA

E-mail contact: rodney *at* ifa.hawaii.edu

The W40 complex is a nearby site of recent massive star formation composed of a dense molecular cloud adjacent to an HII region that contains an embedded OB star cluster. The HII region is beginning to blister out and break free from its envelope of molecular gas, but our line of sight to the central stars is largely obscured by intervening dust. Several bright OB stars in W40 - visible at optical, infrared, or cm wavelengths - are providing the ionizing flux that heats the HII region. The known stellar component of W40 is dominated by a small number of partly or fully embedded OB stars which have been studied at various wavelengths, but the lower mass stellar population remains largely unexamined. Despite its modest optical appearance, at 600 pc W40 is one of the nearest massive star forming regions, and with a UV flux of about 1/10th of the Orion Nebula Cluster, this neglected region deserves detailed investigation.

The Serpens Molecular Cloud

C. Eiroa[1]**, A.A. Djupvik**[2]**, and M.M. Casali**[3]

[1] Dpto. Física Teórica, Universidad Autónoma de Madrid, 28049 Madrid, Spain
[2] Nordic Optical Telescope, Apdo 474, 38700 Santa Cruz de La Palma, Spain
[3] European Southern Observatory, Karl-Schwarzschild-Strasse 2, 85748 Garching, Germany

E-mail contact: carlos.eiroa *at* uam.es

The Serpens cloud has received considerable attention in the last years, in particular the small region known as the Serpens cloud core where a plethora of star formation related phenomena are found. This review summarizes our current observational knowledge of the cloud, with emphasis on the core. Recent results are converging to a distance for the cloud of $\sim 230 \pm 20$ pc, an issue which has been controversial over the years. We present the gas and dust properties of the cloud core and describe its structure and appearance at different wavelengths. The core contains a dense, very young, low mass stellar cluster with more than 300 objects in all evolutionary phases, from collapsing gaseous condensations to pre-main sequence stars. We describe the behaviour and spatial distribution of the different stellar populations (mm cores, Classes 0, I and II sources). The spatial concentration and the fraction number of Class 0/Class I/Class II sources is considerably larger in the Serpens core than in any other low mass star formation region, e.g. Taurus, Ophiuchus or Chamaeleon, as also stated in different works. Appropriate references for coordinates and fluxes of all Serpens objects are given. However, we provide for the first time a unified list of all near-IR sources which have up to now been identified as members of the Serpens core cluster; this list includes some members identified in this review. A cross-reference table of the near-IR objects with optical, mid-IR, submillimeter, radio continuum and X-ray surces is also provided. A simple analysis has allowed us to identify a sample of ~ 60 brown dwarf candidates among the 252 near-IR objects; some of them show near-IR excesses and, therefore, they constitute an attractive sample to study very young substellar objects. The review also refers to the outflows associated with the young sources. A section is dedicated to the relatively small amount of works carried out towards Serpens regions outside the core. In particular, we refer to ISO and to recent Spitzer data. These results reveal new centers of active star formation in the Serpens cloud and the presence of new young clusters, which deserve follow-up observations and studies to determine their characteristics and nature in detail. Finally, we give a short, non-exhaustive list of individually interesting Serpens objects.

The Corona Australis Star Forming Region

Ralph Neuhäuser[1] **and Jan Forbrich**[2]

[1] Astrophysikalisches Institut und Universitäts-Sternwarte, Schillergäßchen 2-3, D-07745 Jena, Germany
[2] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street MS 72, Cambridge, MA 02138, USA

E-mail contact: rne *at* astro.uni-jena.de

At a distance of about 130 pc, the Corona Australis molecular cloud complex is one of the nearest regions with with ongoing and/or recent star formation. It is a region with highly variable extinction of up to $A_V \sim 45$ mag, containing, at its core, the *Coronet* protostar cluster. There are now 55 known optically detected members, starting at late B spectral types. At the opposite end of the mass spectrum, there are two confirmed brown dwarf members and seven more candidate brown dwarfs. The CrA region has been most widely surveyed at infrared wavelengths, in X-rays, and in the millimeter continuum, while follow-up observations from centimeter radio to X-rays have focused on the *Coronet* cluster.

Young Nearby Loose Associations

Carlos A.O. Torres[1], **Germano R. Quast**[1], **Claudio H.F. Melo**[2], **and Michael F. Sterzik**[2]

[1] Laboratório Nacional de Astrofísica/ MCT, Rua Estados Unidos 154, 37504-364 Itajubá (MG), Brazil
[2] European Southern Observatory, Casilla 19001, Santiago 19, Chile

E-mail contact: beto *at* lna.br

A significant population of stars with ages younger than the Pleiades exists in the solar neighborhood. They are grouped in loose young associations, sharing similar kinematical and physical properties, but, due to their vicinity to the Sun, they are dispersed in the sky, and hard to identify. Their strong stellar coronal activity, causing enhanced X-ray emission, allows them to be identified as counterparts of X-ray sources. The analysis presented here is based mainly on the SACY project, aimed to survey in a systematic way counterparts of ROSAT all-sky X-ray sources in the Southern Hemisphere for which proper motions are known. We give the definition, main properties, and lists of high-probability members of nine confirmed loose young associations that do not belong directly to the well-known Oph-Sco-Cen complex. The youth and vicinity of many members of these new associations make them ideal targets for follow-up studies, specifically geared towards the understanding of planetary system formation. Searches for very low-mass and brown dwarf companions are ongoing, and it will be promising to search for planetary companions with next generation instruments.

Star Formation and Molecular Clouds at High Galactic Latitude

Peregrine M. McGehee[1]

[1] Infrared Processing and Analysis Center, California Institute of Technology, Pasadena, CA 91125 USA

E-mail contact: peregrin *at* ipac.caltech.edu

In this chapter we review the young stars and molecular clouds found at high Galactic latitudes ($|b| \geq 30°$). These are mostly associated with two large-scale structures on the sky, the Gould Belt and the Taurus star formation region, and a handful of molecular clouds including MBM 12 and MBM 20 which, as a population, consist of the nearest star formation sites to our Sun. There are also a few young stars that are found in apparent isolation far from any molecular cloud. The high latitude clouds are primarily translucent molecular clouds and diffuse Galactic cirrus with the majority of them seen at high latitude simply due to their proximity to the Sun. The rare exceptions are those, like the Draco and other intermediate or high velocity clouds, found significantly above or below the Galactic plane. We review the processes that result in star formation within these low density and extraplanar environments as well as the mechanisms for production of isolated T Tauri stars. We present and discuss the known high-latitude stellar nurseries and young stellar objects.

Star Formation in Bok Globules and Small Clouds

Bo Reipurth[1]

[1] Institute for Astronomy, University of Hawaii, 640 N. Aohoku Place, Hilo, HI 96720, USA

E-mail contact: reipurth *at* ifa.hawaii.edu

While most star formation occurs in giant molecular clouds, numerous small clouds and Bok globules are known to each harbor one or a few young stars. Studies of such isolated newborn stars offer insights into the star formation process unencumbered by the confusion that often complicates studies of richer star forming regions. In this chapter, a dozen Bok globules and small clouds have been selected for discussion as examples of small scale star formation. Particularly interesting or well studied cases include BHR 71, CG 12, B62, B93, L723, and B335.