Appendix 2 - CDS Science Team Achievements 2011-2016 as presented to HCERES

Scientific output

1) Stellar Astronomy

Ada Nebot characterises the X-ray properties of the stellar content of the Milky Way by using 'learning samples' to determine the nature of the serendipitously discovered sources by the XMM-Newton. The first study [ACL-E3-67] focused on sources with optical and infrared counterparts at low and intermediate galactic latitudes (|bII|<20). Optical spectroscopic follow-up observations revealed that about 30% of the X-ray sources are stars (single or in binary systems) and have soft X-ray emission. Although the hard X-ray population is dominated by extragalactic objects, a population of high-mass stars with hard X-ray emission was revealed. This lead to a second study [ACL-CT-46] where she investigated the nature of X-ray sources with infrared counterparts and having X-ray spectra typical of hard X-ray high-mass stars. Infrared spectroscopic pilot observations of a small sample of these sources confirmed them as high-mass stars and more observations were carried out in April 2016. She used these learning samples to statistically classify XMM-Newton sources with optical and/or infrared counterparts. The next step is to update the X-ray count model developed by Guillout et al. 1996 A&A 316,89 for ROSAT observations and based on the evolution synthesis population model from Besancon and to compare our observations with the expectations. Establishing the observed properties of the stellar populations and comparing with model predictions will allow us to constrain (local ~2 kpc) stellar formation rate during the last ~2 Gyr, estimate the way the scale height increases with age, reveal young star clustering, quantify the contribution of old binaries, make some inference on the nature of the galactic ridge population and also search for outliers (pre-LMXB, wind accreting binaries, wind colliding binaries). While the work done for ROSAT allowed all-sky studies up to 300 pc, with XMM-Newton we will study up to 2-3 kpc.

The activity of Cecile Loup is focused on understanding the mass-loss of Asymptotic Giant Branch (AGB) stars, and on young stellar objects (YSO) using large infrared surveys. The IRAS whole sky survey in the mid- and far-infrared in the 80s has been a major breakthrough in astronomy. It is still the basis of our knowledge on the mass-loss of AGB stars and on YSOs, however, combining IRAS with modern infrared surveys is not straightforward due to the poor resolution and astrometry of IRAS. To address this, Cecile has developed a new method to identify IRAS point sources in the AKARI (MIR and FIR) and WISE (MIR) surveys. The blending problem is solved by searching at the resolution of each survey, and by measuring the consistency between the fluxes. About 30% of the IRAS sources turn out to be a blend, especially in the FIR. A comparison of well identified IRAS sources with the content of SIMBAD shows that a band centered at about 20-30 microns is required to distinguish between AGB stars and YSOs. But the most powerful way is to have a FIR band, which was the basis of the IRAS survey (Loup, in preparation).

Cecile's work provides a new basis for the identification of AGB stars in modern (very) large surveys, including 2MASS and Spitzer surveys, and to derive their mass loss rate. Application of these methods to OH/IR stars reveals that most of them are not well detected by GLIMPSE because they saturate the receivers. It also confirms that Spitzer color criteria often used in the literature to distinguish between heavily obscured AGB stars and YSOs is not supported by observational evidence (Loup, in preparation).

2) Milky Way and Nearby Galaxies

Laurent Cambrésy pursues research into the interstellar medium and the star formation in the Milky Way using multi-wavelength studies and statistical analysis. An investigation of the Rosette molecular complex led to a reconsideration of the status of the paradigm for triggered star formation in this region [ACL-E1-25]. The statistical approach permitted the identification of 11 clusters, two of them new discoveries, for a total of about 5000 members. An age estimation was obtained from the spectral energy distribution of a sub-sample of these young stellar objects using 2MASS, UKIDSS and WISE, showing that the age gradient predicted by a triggered star formation scenario is not observed in the Rosette complex. This result indicates that the spatial distribution of sources is not enough to conclude on the star formation process, and that further analysis on the age or on the gas velocities must be conducted as well.

L. Cambrésy is also involved in 3D studies in the interstellar medium [ACL-E1-33] and is part of the VIALACTEA program (FP7-SPACE, 2013-2016). His task is to provide a 3D extinction map of the galactic plane. A first version of this map based on the 2MASS catalogue and the Besançon model has been delivered to the consortium. Further developments are in progress to include the GLIMPSE mid-infrared catalog. The aim is to compare the 3D extinction with the submillimeter dust emission from Hershel/Hi-GAL to better understand the distribution along the line-of-sight and the connection between the interstellar medium and the star formation.

Arnaud Siebert's research is focused on the Milky Way with an emphasis on the kinematical and dynamical effects of perturbations on the Galactic velocity field. This follows from the discovery of non-circular motions in the nearby 2kpc Galactic disc using the RAVE spectroscopic survey in 2011 [ACL-CT-11]. They showed that using quasi-static logarithmic spiral arms of the Lin & Shu type, the observed mean velocities can be properly recovered, setting new constraints on the properties of the local spiral structure [ACL-CT-19]. While, the previous works focused on the in-plane motions (two dimensional), an extension of this work into the third dimension revealed non-zero vertical motions that resemble compression/rarefaction waves [ACL-E2-134]. Using 3 dimensional particle-test simulations, it appeared that this observed velocity structure is likely a breathing mode generated by the spiral perturbation, whose existence is confirmed by an analytic extension in 3D of the density wave theory in the cold disc case [ACL-CT-39].

If spiral arms are able to reproduce the observed velocity field, they are not the sole internal perturbers of the Galactic disc. The central bar is also known to produce strong effects on the local velocity distribution. Hence, the previous theoretical developments were also carried out to test whether the bar could contribute to the observed "anomalies". While the bar can have strong effect for the in-plane motion, they showed that its effect on the vertical motion is marginal [ACL-E2-134]. Future theoretical work together with the "Galaxies" team are underway to construct perturbed distribution functions of a Galactic disc with multiple perturbers and a proper handling of resonances to help interpret the Gaia and Weave data (see also the "Galaxies "team achievements in Sect. 2.2).

Caroline Bot and PhD student Jeremy Chastenet study dust emission of nearby galaxies and in particular the Magellanic Clouds. The goal is to understand dust properties at different metallicities by modeling their infrared spectral energy distributions (SED). Herschel and Spitzer observations enable a large wavelength coverage of dust emission from 3.6 to 500μm. Many studies have been done to analyse this dust emission in the Magellanic Clouds in terms of dust masses, heating or grain size distribution. However, the shape of the far-infrared peak is challenging to reproduce with current full dust models, especially in the Small Magellanic Cloud (SMC). Furthermore, the solutions obtained depend on the dust model or on the assumptions made for the modeling (e.g single or mixing of radiation fields) and even on the fitting technique. In this context, [ACL-E1-32] presented a fitting scheme (now called Dust-BFF) that carefully takes into account the different sources of uncertainties and their correlations between bands. This scheme was tested on the Magellanic Clouds with three different simple dust models on the Herschel-only SEDs [ACL-E1-31].

As part of his thesis (started in Oct 2014, co-directed by F. Genova, CDS and K. Gordon, STScI), Jeremy Chastenet has modeled the point-by-point SEDs in the Magellanic Clouds as seen by Spitzer and Herschel. The Dust-BFF fitting scheme is applied in a fully consistent way to two full dust models (DUSTEM and THEMIS) and different modeling assumptions (single radiation field, power law mix of radiation fields, change of the dust grain size distribution). The results show that the THEMIS model reproduces best the shape of the far-infrared to sub-millimeter emission in the Magellanic Clouds. One important result obtained with this model in the SMC is that the amount of silicate grains with respect to carbonaceous grains must be different (lower) than in the solar neighborhood. The results in the Large Magellanic Clouds are intermediate between the SMC and Milky Way. A paper presenting this work is in preparation.

In parallel, Caroline Bot has worked heavily on infrared data in the Magellanic Clouds. By comparing IRAS-IRIS with DIRBE data at 100μm, she uncovered a systematic difference (at the 15-30% level) in the large scale photometry in small specific regions of the sky (the Magellanic Clouds, but also regions of the galactic plane). This finding has led to a reprocessing of the IRIS data at 100μm which improves the allsky IRIS-DIRBE consistency and a publication is underway.

3) Extragalactic

Bernd Vollmer develops different studies in the domain of cluster galaxies, galactic centres and galaxy evolution with a wide set of collaborations. One project is linked to the evolution of cluster galaxies, with the development of a code that simulates the interactions of a spiral galaxy with its environment, and a successful observational program in CO, HI and continuum. It is now possible to predict the UV emission of a perturbed spiral galaxy. The comparison between observations and simulations has led to a better understanding of the reaction of the multiphase ISM and subsequent star formation to ram pressure compression [ACL-E1-22], [ACL-E1-19], ACL-E1-28], [ACL-E1-57]. The direct ISM-ISM collision of the Taffy galaxies, a very rare phenomenon, has been successfully reproduced by the dynamical model, leading to a better understanding of the reaction of the ISM to such a violent interaction [ACL-E1-17].

Bernd also studies the physics and dynamics of gas in the Galactic centre and in AGNs. An analytical and dynamical model of gas in the central 20pc of the Milky Way has been developed, which has then been generalized to active galactic nuclei [ACL-E1-26]. In collaboration with the image processing group at Strasbourg University, an algorithm for the detection of low surface brightness galaxies in images (MARSIAA), which is based on multi-scale Markovian modeling, has been applied to NGVS multiband images. The capabilities of this algorithm have been assessed and its complementarity with other algorithms has been shown [ACL-E1-30]. Together with his PhD student, Francois Nehlig, Bernd also studied the HI distribution and kinematics of the highly-inclined local spiral galaxy NGC 2683 by means of detailed 3D modeling (Vollmer et al. 2016, accepted by A&A).

The scientific activity of Pierre Ocvirk spans the topics of galaxy formation during the epoch of reionization, radiative feedback effects on satellite galaxies, and numerical simulations of reionization. Pierre investigates hydro-radiative processes (photo-ionization, photo-heating), their feedback on star formation activity, and in particular their imprint on the properties of present-time, low mass galaxies, such as the smallest satellites of the Milky Way.

Radiative feedback is currently one the favored processes for explaining the missing satellite problem. Photo-heating of the intergalactic medium by the UV background during and after the Epoch of reionization stopped rendered gas accretion on low mass haloes inefficient. The latter are therefore thought to have stopped forming stars at z=6 or shortly thereafter, producing a large number of dark and sterile low mass haloes, in agreement with the small number of satellite galaxies around the Milky Way and M31. Pierre showed with simple semi-analytical models that the geometry of the UV radiation field during reionization (uniform or radial, endogenous reionization) could leave an imprint on the properties of the satellite system of a galaxy [ACL-CT-3]. These models were then made more realistic by using N-body SPH simulations of the formation of the local group performed by the CLUES collaboration (Constrained Local UniversE Simulations), of which Pierre is a member since 2011, post-processed with a UV radiative transfer code [ACL-CT-24, ACL-CT-32]. More recently, PhD student N. Gillet (supervised in collaboration with Dominique Aubert, galaxy team) used these simulations to study the occurrence of vast planes of satellites such as those found by Ibata [ACL-E2-75] in the Milky Way and M31. He found that simulations indeed predict planes similar to those observed, however not exactly as thin, and that such planes are half-consistent, and half-fortuitous alignments with random satellites, making such planes short-lived [ACL-CT-50].

To improve further the realism of reionization scenarios of the local group of galaxies, Pierre Ocvirk, in collaboration with an international team of researchers including Paul R. Shapiro and Romain Teyssier, obtained 50 million core hours on the Titan super computer of the American Department of Energy. This allowed the collaboration to perform the largest yet GPU-driven hydro-radiative simulation of galaxy formation during the Epoch of Reionization. 8192 GPUs were used for about 10 days of computation, producing 2 PetaBytes of data. The simulation describes self-consistently, for the first time on such a scale (913 Mpc volume on a 40963 grid) the formation of galaxies, the propagation of the UV light produced by their stars through the IGM and its subsequent reionization, and the feedback of this radiation on star formation in low mass haloes, susceptible to radiation quenching (Cosmic Dawn simulation, Ocvirk et al.2015, submitted, arxiv:1511.00011). Pierre Ocvirk is participating to ANR Blanc ORAGE (hydrOdynamics and RAdiation in GalaxiEs, 2014 2018), which allowed him to recruit PhD student N. Deparis, co-supervised with Dominique Aubert from the Galaxies team. He is working on EMMA [ACL-CT-44], a new code for accelerated hydro-radiative simulations of galaxy formation. This code will be used in the second iteration of the Cosmic Dawn simulation, for which a massive 70 million core hours were again allocated on Titan for 2016.

Mark Allen works on the analysis of ionized gas in astrophysical systems in order to probe the physical processes of shocks and photoionization. He supports a widely used library of fast radiative shock models (Allen et al., 2008 ApJS, 178, 20) that have be applied to AGN, supernovae, and planetary nebulae (>250 citations). With collaborators he gained 15 orbits of observing time with the Hubble space Telescope in Cycle 19 to image merging galaxy systems in key shock and photoionization sensitive diagnostic lines [OII], [OIII], Hbeta, [NII]+H-alpha, [SII] and [OI]. One highlighted results is the discovery of an off-nuclear superbubble in Arp 220 [ACL-E1-38].

Information Research and Processing

Sébastien Derriere made important contributions to scientific metadata standardization in the frame of the Virtual Observatory project to maximize interoperability across global astronomy services. Achievements in this period include the international standardization of units within the IVOA (IVOA Recommendation – Units in the VO, 2014, Eds: S. Derriere, N. Gray), standardization of information about astronomical photometric systems (IVOA Recommendation – Photometry Data Model, 2013, including S. Derriere, M. Allen, M. Louys amongst the authors). Also standardization of spectral metadata in the Spectrum Data Model (IVOA Recommendation 2011, including S. Derriere as an author). S. Derriere has implemented the scientific metadata in the VizieR registry for describing and discovering catalogues, and has also led the application of CDS widgets and services to the dedicated data portal for the ASTRODEEP FP7-Space project, along with contributions to articles on the ASTRODEEP Frontier Field catalogues and photometric redshifts.

Other highlights with contributions from the science team include the fast and scalable catalogue CDS cross-match tool was developed and is now in production [AFF11-36, AFF12-10]. A generalization to cross-matching multiple catalogues has been done by F-X Pineau and S. Derriere in the frame of the ARCHES FP7 European project, with a major paper submitted in June 2016. The development of the Hierarchical Progressive Surveys (HiPS) system brought CDS scientific and technical expertise together to enable new ways of working with all-sky astronomy data [ACL-E1-39].

CDS science team contributions to the development of reference astronomy services and interoperable systems for astronomy, in particular the CDS services and the Virtual Observatory are described in the OSU application.

Academic appeal and reputation

The CDS is a premier astronomy reference data centre with engagements with major astronomy journals, space agencies, observatories and other complementary international astronomy data centres. CDS has lead the Euro-VO project with 5 European partners to win joint funding in EC Framework programs. The main project in the period, CoSADIE project led by Françoise Genova was one of the laureates of the 2015 Etoiles de l'Europe Prizes created by the French Ministry of 'National Education, Higher Education and Research' to reward French teams that coordinate European projects as part of the research and innovation framework programme. CDS staff play leading roles in the IVOA, the international network of 20 members for astronomy data and services. CDS contributes to generic infrastructures for the use of data and information in society via participation and leadership in RDA and ICSU-WDS.

We present below a brief list of the CDS involvement and leadership roles, as well as memberships of scientific councils, international review committees and networks.

Involvement in current and future space observatories

- FLARE (M5 ESA mission call), Co-leader of the Milky Way Science Group (LC)
- SPICA (M5 ESA mission call), member of Local Galaxies Working Group (CB)

Scientific councils, review committees and international networks

- Member of the IVOA
    - French representative on the Executive Board (FG)
    - Chair of the Standing Committee on Standards and Processes (FG)
    - Chair of the Data Curation and Preservation Interest Group (FG)
    - Chair of the Standing Committee for Science Priorities 2011- (MA)
    - Executive Secretary 2009-2013 (MA)
    - Lead Editor of the IVOA newsletter 2008-2014 (MA)
    - Chair of the Semantics Working Group 2008-2012 (SD)
    - Chair of the Semantics Working Group 2015 – (ML)
    - Chair of the Data Model Working Group 2007-2011 (ML)
    - Chair of the Applications Working Group 2014-, deputy Chair 2012-2014 (PF)
    - Chair of the Grid and web Services Working Group 2013-2015, deputy chair 2011-13 (ASchaaff)

  - Chair of the Data Access Layer Working Group 2014-, Deputy Chair 2013-14 (FB)
- Co-ordinator of the Euro-VO International Cooperation Empowerment (EuroVO-ICE, Project 261541) Call INFRA-2010-3.3, 2010-2012 (FG)
- Co-ordinator of the Collaborative and sustainable Data Infrastructure for Europe (CoSADIE, Call INFRA-2012-3.3 Research Infrastructures, project 312559, 2012-2015 (FG)
- Member of the Research Data Alliance Europe project (Formerly iCORDI International Collaboration on Research of the Data Infrastructure, Coordination and Support Action, Project 312424, Call FP7-INFRASTRUCTURES-2012-1, 2012-2015 (FG).
- Member RDA Europe 2 (coordination and Support Action, Project 632756, Call FP7-INFRASTRUCTURES-2013-2) (FG)
- Member of the Research Data Alliance Technical Advisory Board (FG)
- Member of the Data Seal of Approval Board 2016- (FG)
- Member of the International Council for Science, World Data System, Scientific Committee 2009-2012 (FG)
- Member of the International Council for Science CODATA Executive Committee, 2010-2012 (FG)
- ASTERICS (Astronomy ESFRI and Research Research Infrastructure Cluster) Call H2020-INFRADEV-1-2014-1, Lead of Work Package 4 'Data Access, discovery and Interoperability' 2015-2019 (FG, MA)
- Member Scientific Council of the Action Spécifique Observatoire Virtuel France (FG)
- Member of the Astronomy and Astrophysics (A&A) Board (FG)
- Member ASTRONET Infrastructure roadmap panel D, 2014 (MA)
- Member WEAVE project review panel 2015, (MA)
- Member of HCERES committees (LC)
- Member of the VIALACTEA (FP7) project Steering Committee (LC)
- Member of the CNU section 34 (2016-2020) (CB)
- Member of Scientific Expert Committee (CES) of Univesité de Strasbourg 2010-2013 (CB)
- Member of the review committee a FP7 project (2014) (SD)
- Member of the Jean-Marie Mariotti Centre (JMMC) Scientific Council 2013-2016 (SD)
- Member of AERES evaluation committee 2013 (BV)
- Coordinator of INSU-AA-2014 data centres prospective (BV)
- Member of the CNRS INSU ANO5 (BV)
- Member of the IAU Working Group on designations (BV)
- Member of the RAVE consortium (AS)

CDS Science Team Prospectives as presented to HCERES

4.3 CDS

In the 2018-2022 period CDS staff scientists will pursue a wide range of research covering stellar astronomy, the Milky Way and nearby galaxies, extragalactic astrophysics, and also science driven research on astro-informatics and information processing.

These research projects include involvement in a number space missions that will be active in this period, notably Gaia and eROSITA. Our research plans also include significant exploitation of data from Spitzer, Herschel, XMM-Netwon, and HST, as well as reprocessed versions of legacy data sets such as IRAS. CDS staff is also involved in the preparation of future missions such as the FLARE mission being proposed in the ESA M5 call.

CDS staff research will make use of European and international ground based observatories for targeted programs and also participate in large survey projects. Involvement with new instruments such as WEAVE will contribute to a new era of spectroscopic surveys, and the combination of astrometric and spectroscopic surveys is a particular strength that will reinforce CDS activities for astronomical object identification.

CDS staff research plans include theoretical modeling and numerical simulations that will build on experience of using the most powerful HPC resources available to explore the epoch of re-ionization. Capabilities for MHD and ionized plasma modeling, along with analytic approaches are also strengths of the CDS science team.

The scientific programs of the CDS science staff members are outlined below. As the CDS science team has been built with a strategy of covering a wide range of astrophysics research in order to support the CDS services, the individual research programs of CDS scientists are diverse. This is a strength of the CDS which is supported by maintaining collaborations within the observatory and with external colleagues, groups and projects. (Scientific data sharing leadership and research activities related to CDS services and data infrastructures, are outlined in the Osu document.)

4.3.1 Stellar Astronomy

Ada Nebot will pursue research on the physics of X-ray emitting stars using current and future X-ray surveys (XMM-Newton, eROSITA – to be launched 2017) and models of stellar populations in the Milky Way galaxy. In particular to advance our knowledge of the effects of magnetic braking and the contributions of different stellar components to the total X-ray emission of the galaxy. This work will be done together with C. Motch and P. Guillout (see also 4.2.1.3.b), and also with A.C. Robin and her colleagues who develop the Besancon model of the Milky Way. Ada will also apply an all-sky approach using a combination of eROSITA and Gaia observations that will provide new insights via higher number statistics for X-ray emitting stars, with the potential to reveal large scale local structures such as the late type stellar component of the Gould Belt, and to provide constraints on the space density of RSCVn binaries. The eROSITA work will be done with the chairs of the eROSITA stellar working group at Hamburger Sternwarte; J. Robrade and J. H. M. M. Schmitt.

Cécile Loup will undertake research aimed and providing insights on Asymptotic Giant Branch (AGB) stars and Long Period Variables (LPV) with Gaia. AGB stars pulsate and lose mass at relatively high rates (about 10-7 to 10-4 MSUN/yr). Their evolution and chemistry depend on their initial metallicities and initial masses, and they contribute significantly to the chemical enrichment of the interstellar medium. Hipparcos could only observe very few AGB stars because the limiting magnitude was too bright. Gaia will obtain the distances of a statistically significant sample of AGB stars and LPV. An initial sample has already been built from optical and infrared surveys, including the difficult task of identifying the many historical carbon-rich and oxygen-rich AGB stars, and LPV (especially Miras variables) that had poor astrometry. Distances that will be measured by Gaia will make it possible to test the Mira/SRa period-luminosity relations, to improve our knowledge of their mass-loss rates, and to better constrain evolutionary models. Other work related to Gaia will be coordinated with CDS team efforts to improve methods for cross-identifications taking into account the resolution and the blending, with benefits for global astrometry in CDS SIMBAD and Vizier services.

4.3.2 Milky Way and Nearby Galaxies

Laurent Cambrésy will undertake 3D extinction mapping and analysis of dust properties in the Galactic plane using large surveys at different wavelengths, and also study of the formation and evolution of embedded star clusters.
During the VIALACTEA FP7 program (completed on Oct 2016) L. Cambrésy and H. Arab produced a 3D extinction map of the Galactic plane. The goal for the next years is to exploit this extinction map together with other VIALACTEA products, such as the column density map based on the dust emission, in order to constrain the dust optical properties (temperature, emissivity) and their variations along the line of sight. This project is in close collaboration with AIM/CEA and Utinam/Besançon.

The distribution and luminosity of the young stellar objects provides us with information on the star forming region status. A project has started with C. Boily to understand the evolution of these complex regions. In particular, the impact of massive stars in the cluster evolution is still debated. Numerical simulations of star cluster dynamics, stellar evolution and observational constraints will allow us to interpret the morphology of the star clusters in the Galaxy in term of member masses, ages and kinematics (see also 4.2.1.3.b).

L. Cambrésy is co-leader of the Milky Way Science working group of the FLARE mission proposed for the ESA M5 call. In this group we propose to study the dark cloud structure and the content in the Gould Belt, to perform a 3D tomography of the Galaxy ISM, and to make a census of young clusters in the Galactic disk.

Arnaud Siebert will pursue various research projects on galactic dynamics using spectroscopic and astrometric surveys: RAVE, Gaia, WEAVE and possibly Theia. These studies will investigate the effect of perturbations on the disc velocity field, mass distribution and other fundamental parameters (see also 4.2.1.3.a).

The time period 2018-2022 will see the release of large Galactic surveys that will allow us to study the structure and dynamics of the Milky Way disc and its mass distribution in great detail. Arnaud Siebert will be involved in both the Gaia mission and WEAVE instrument and will use the resulting catalogues to pursue the study of perturbations of the disc, such as the Galactic bar or spiral arms, in order to put new constraints on their physical parameters. Understanding the details of these internal perturbations will be necessary as they can have a significant impact on the measurement of the Galactic fundamental parameters such as Ro, the distance to the Galactic center, and vco the rotation velocity at Ro. These parameters are of prime importance in many fields of astrophysics such as Galactic dynamics and structure, and also for attempts to directly detect dark matter. Arnaud Siebert will therefore use the refined perturbation parameters together with a full dynamical model of the Galactic disc and large scale astrometric data to refine these two parameters. These projects will be pursued in close collaboration with B. Famaey and O. Bienaymé (see 4.2.1.3.a).

Caroline Bot plans to investigate the extended infrared emission and dust properties of nearby galaxies by using different dust models in a systematic way on the combination of data from multiple instruments, point by point in these nearby galaxies. The key to this approach is to improve the characterization of foreground cirrus emission so that the diffuse dust emission can be measured much more accurately.

This will build on her work of identifying biases in the IRAS-IRIS photometry at 100um, and her reprocessing of the whole IRIS all-sky survey. In collaboration with M.-A. Miville-Deschenes at IAS and Guilaine Lagache at LAM the reprocessing will be extended to the other IRAS bands (12, 25, 60um) and improve the zodiacal light subtraction in the data. This data will be used together with the THEMIS dust model (in collaboration with A. Jones and N. Ysard at IAS) and the Dust-BFF fitter (in collaboration with K. Gordon and J. Roman-Duval at STScI) to study the variations of dust emission from the infrared to millimeter in the Milky Way high latitude cirrus. This study will be done in two ways: on large scales with the new IRIS data and Planck data, and on smaller scale in the foreground region of the Magellanic Bridge, with Spitzer and Herschel images. This better understanding of the foreground cirrus emission variations will enable to subtract them more efficiently from the Spitzer and Herschel maps of the Magellanic Clouds. The Spitzer and Herschel data will also be re-reduced by K. Gordon, K. Misselt and J. Roman-Duval and anchored to Planck and IRIS photometry predictions on large scales by Caroline Bot. Using this better data set and cirrus subtraction, C. Bot will study the extended diffuse dust emission around the Magellanic Clouds and study whether and how dust properties vary from these galaxies outskirts to their denser regions

4.3.3 Extragalactic

Bernd Vollmer will continue his work on the physics of ram pressure stripping of the gas in Virgo cluster spiral galaxies. This work will build on MHD calculations that have been done in collaboration with Marian Soida (Krakov University) to study the evolution of the large-scale magnetic field during the interaction of a spiral galaxy with its cluster environment. This will lead to the publication of a model atlas of polarized radio continuum images. In a second step, the star formation rate and its associated UV emission of the numerical simulations will be calculated and compared to existing observations. Furthermore, it is planned to study the influence of adiabatic ISM compression on star formation. Virgo spiral galaxies are an ideal laboratory to do so. Bernd Vollmer will also pursue projects to gain insight into the physics of large-scale gas compression in galaxies using polarized radio continuum emission as a tracer of ISM compression, with JVLA S- and L-band data already collected in preparation for this work. Bernd Vollmer will continue the development of an analytical clumpy accretion disk model in which the molecular line emission is calculated from the physical parameters of the gas clouds on all of the relevant length scales. This model has already successfully reproduced the multi-transition CO, HCN(1-0) and HCO+(1-0) emission of samples of local spiral galaxies, ULIRGs, sub-mm, and high-z star-forming galaxies. It is planned to extend this model to thick obscuring gas disks (tori) in active galactic nuclei.

Mark Allen maintains an interest in the application of shock and photoionisation models to a wide range of astrophysical systems. Supersonic motions are a common phenomenon in the Universe, and the kinetic energy of such motions can be dissipated through radiative shocks. Gas cloud collisions, HII region expansion into interstellar medium, outflows from young stellar objects, supernovae, outflows from active and starburst galaxies, and collisions between galaxies are all examples of astrophysical situations in which radiative shock waves provide an important component of the total energy budget. Following the widespread use of his library of fast shock models, the next generation of shock models will be pursued with collaborators at the Australian National University. He will also continue his work in observational (HST) projects to obtain high spatial resolution observations of active and merging galaxies.

Pierre Ocvirk will develop his activities in numerical simulations of galaxy formation, maintaining an emphasis on coupled radiation-hydrodynamical processes, in particular during the Epoch of Reionization (see also 4.2.1.1). Such simulations must be large enough to describe the process of reionization properly, and still have enough resolution to describe realistically the sources, i.e. forming galaxies. To achieve this, Pierre Ocvirk maintains and upgrades the GPU-optimized RAMSES-CUDATON and will contribute to the development of the new EMMA code (see 4.2.2.3), developed by D. Aubert of the "Galaxies" team (future HE-GAL merged team). These codes will be deployed on the largest supercomputers available (e.g. Titan at Oak Ridge National Laboratory and its successor Summit, or Piz Daint in Switzerland) to understand the physics of galaxy formation during the EoR and make predictions for the future high redshift observatories such as JWST, WFIRST, SKA, and when possible low redshift, deep, local group observatories such as LSST, which will probe the very faint end of the local galaxy luminosity function. These new simulations are heralded by the gigantic Cosmic Dawn simulation (Ocvirk et al. arXiv:1511.00011), and will be performed within international collaborations.

4.3.4 Astro-informatics and information processing and data sharing

Sébastien Derriere works at the interface between astronomy and information research, a rapidly evolving field that enables new approaches to astrophysics via scientific interoperability of different kinds of data, information and services. Sébastien's work is focused on the development of core scientific metadata for the description of astronomical services that will improve information research across CDS services, and globally at the international Virtual Observatory level. This involves the development and maintenance of standard vocabularies (UCD, astronomy thesaurus), and standardized metadata for data sharing and interoperability of future tools for advanced visualization and data exploration. In 2018-2022 these developments will be realized in astronomy data portals, starting with the CDS portal and other project-specific ones. Leveraging on semantic techniques for information research, smart features for information retrieval will be implemented, facilitating the task of researchers in the context of an ever-growing number of data sources. These portals will provide access to new large catalogues at CDS, both in VizieR and the Xmatch service. Sébastien will also work on astronomical source cross matching with multiple parameters (other than positions and errors – for example fluxes and prior on SED shape) for multiple large catalogues, in order to build a reference master catalogue based on the GAIA catalogue. This master catalogue will be used for Galaxy structure and kinematics studi