

European Science Foundation
Standing Committee for Physical and Engineering Sciences (PESC)

ESF PESC Exploratory Workshop on
**Tracing Dust in Spiral Galaxies:
Radiative Transfer Studies in The
Dawn of a New Generation of
Observing Facilities**

SCIENTIFIC REPORT

Ghent, Belgium, 13 - 17 May 2007

Convened by:
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Executive summary:

The workshop was convened by Dr. Maarten Baes (University of Ghent, Belgium), Dr. Simone Bianchi (INAF-IRA, Italy) and Dr. Emmanuel Xilouris (National Observatory of Athens, Greece). It was organized in the conference centre *Het Pand* of the University of Ghent, a historical building situated in the centre of the city of Ghent. A dedicated web site has been set up with information about the meeting (including the presentations made during the workshop in power-point or pdf format):

<http://www.arcetri.astro.it/radtran>

The main goal of the workshop was to bring together astronomers interested in studying the effects of solid particles (dust grains) in the physics of spiral galaxies. Researchers with expertise in modelling the radiative transfer of light through dust were confronted with observers, and a few unsolved issues were pointed out during the discussion. The workshop brought together most of the groups actively working on the subject in Europe, and laid the foundation of future collaborations. In particular, joint proposals have been planned to make use of the ESA infrared space telescope HERSCHEL, which will be launched in 2008.

The workshop has funded by the European Science Foundation (EW06-083). All participants were provided with accommodation in one of four hotels in the city centre, with easy access to the conference venue and to the historic centre. A lunch (during a boat trip on Ghent canals) and the conference dinner were directly organized by the convenors, while an allowance was provided for the rest of the meals. Coffee breaks were provided in a room next to the conference one. Personnel of the University of Ghent set up internet connection and computers for use during the workshop. Travel support was provided to a few participants in need of it, while the rest have travelled on personal research funds.

The meeting was attended by 29 researchers from 10 different countries. Almost all of the participants arrived on May 13th. The meeting started on the morning of May 14th and ended in the afternoon of May 16th, for a total of 6 morning and afternoon sessions. All people attended all sessions, including the final one in which future actions and collaborations were planned. Due to the lack of an ESF representative, an introduction to ESF and its instruments was given by the convenors. During the meeting, plenty of time was dedicated to discussions, both at the end of each presentation and at the end of each session. Discussions were favored by the informal setting of the workshop and were lively, though friendly. Proficuous interactions among researchers also occurred during coffee breaks and especially after the official end of

evening sessions, when researchers met for dinners and after-dinner.

events. Indeed, many participants have appreciated the cozy atmosphere of the workshop, especially when compared to the more rigid protocol of larger conferences.

Scientific content of the event:

Despite the enormous importance of dust in the physics of spiral galaxies, there are still several open questions: how much dust is present? How is dust distributed with respect to the stars and the gas? What environments are responsible for dust extinction/emission in different wavelength regimes? What are the properties of dust responsible for the bulk of emission? Are there differences in the dust contents of galaxies of different morphological type? The workshop brought together researchers working on different astrophysical fields related to dust and to galactic structures, with the aim of identifying the best observing and modelling strategies to solve the open issues.

The first, opening, session was devoted to the presentation of radiative transfer models in galactic disk, a field which has been extensively explored by a few European groups in the last decade. The comparison between models and observations in optical wavelengths has shown that the disk of spiral galaxies contains only a limited amount of dust, making them almost transparent to the stellar radiation (unless they are viewed at very high inclinations). This is in contrast, however, with observations of dust emission in the infrared, which need a considerably larger amount of solid grains in the interstellar space. Several solutions had been proposed during the workshop (uncertainties in dust emission properties, additional dust components, medium inhomogeneities) which will probably find answers with the next generation of infrared observing facilities.

In the second session the current knowledge of dust extinction and emission properties in our own galaxy, the Milky Way, were reviewed. A particular emphasis was given to the change of dust properties with the environment and during the grain life-cycle.

The third session was devoted to observations of dust emission: reviews were presented on observations made with submm and space-based far-infrared instrumentation, e.g. SCUBA and SPITZER. So far observations have shown that different galactic environments show different kind of dust emission, but a detailed analysis is available only from emission by warm dust in dense environments ($T > 40\text{K}$). Future instrumentation will have the necessary sensitivity and adequate spatial resolution to undertake detailed studies of the bulk of dust grains, which have colder temperatures ($T < 20\text{-}30\text{K}$)

and may reside in a more diffuse medium. The main observing facilities (SCUBA-2, LABOCA, and HERSCHEL) which are soon becoming available were presented in this session, together with a description of the observing projects which have been already planned in extragalactic astronomy, and of the opportunity windows for a joint collaboration among the researchers attending the workshop. All participants of the workshop were quite impressed when, for the first time, they could observe, almost in real time, via the internet using the submm camera LABOCA at APEX (Chile) which was just commissioned and is now in a testing phase. This event was organized by one of the workshop participants responsible for this instrument.

One outcome of this workshop was the unanimous agreement in defining the different dust temperature components that are detected in galaxies, something which was quite confusing for a long time now. In particular, it was agreed that there are three main temperature components [namely, a warm (~ 40 K), a cold (~ 20 K) and a very cold (< 10 K)].

In the fourth session the problem of the evolution of galactic structures was tackled, which is important for both modelling of local galaxies and for studies of the variation of the dust content with cosmic time. This issue, which is of paramount importance given the amount of theoretic work and observational time devoted to studies of cosmological evolution, clearly need a detailed modelling of the effects of dust in local, well known, objects.

In the fifth session studies of the distribution and content of atomic and molecular gas in galaxies were presented. The well established connection between molecular gas and dust suggests that the gas distributions can be used as proxies of different dust components. In particular, some recent surveys have the necessary resolution for a detailed comparison with dust emission observations from future facilities.

In the final, sixth, session, a summary of all key problems was presented and collaborations were planned. In particular, it was decided to propose two large projects to use the HERSCHEL satellite: in the first, a survey of nearby clusters of galaxies will allow to study the global amount of dust emission as a function of galactic morphological type; in the second, deep observations of nearby objects will reveal the detailed structure of cold dust emission and assess the correlation with the extended atomic gas distribution. Both proposal will also address the problem of the presence of dust in the intergalactic medium, and assess its effects on the observations of the distant universe. Modellers also agreed on comparing simulations obtained with different methods.

Assessment of the results:

The workshop was very useful, as it allowed to strengthen or establish collaborations among the participants. Through it, observers had become aware of the problems involved in modelling the dust content of a galaxy, while theoreticians got glimpses of how details of the models could be constrained with available or shortly coming observing facilities.

While discussing of future collaborations, it emerged that the problem of the dust effects in galaxies, though extremely important in local and cosmological studies, lacks an appealing *big question* that could make it competitive with other astrophysical problems (e.g. formation of the first structure in the Universe or planet formation) when applying for funding for big projects. Because of this, it was decided to converge collaborative efforts on delineating observing proposals which could, on one hand, help in understanding the key problems in dusty galaxy modelling, while on the other constitute *legacy* dataset of interest for the whole extragalactic community.

Final Programme

Sunday 13 May 2007

Evening *Arrival and accommodation in the hotels*
20:00-22:00 *Dinner*

Monday 14 May 2007

09:00-09:15 Welcome by Convenors
09:15-09:30 Description of ESF instruments (by the Convenors)

Session: Radiative Transfer & Galaxy modelling

09:30-10:00 **Nick Kylafis**, Radiative transfer in spiral galaxies
10:00-10:30 **Maarten Baes**, Monte Carlo Radiative Transfer modelling of dusty disks
10:30-11:00 *Coffee break*
11:00-11:30 **Juergen Steinacker**, Image modelling of complex dusty structures
11:30-12:00 **Simone Bianchi**, Radiative transfer in a clumpy disk
12:00-12:30 **Angelos Misiriotis**, Dust in near-by edge-on spiral galaxies from the 2MASS Large Galaxy Atlas
12:30-13:00 **General discussion**
13:00-15:30 *Lunch break including a boat trip on Ghent canals*

Session: Dust in the Milky Way

15:30-16:00 **Emmanuel Xilouris**, Modelling the ISM in the Milky Way
16:00-16:30 **Anthony Jones**, Dust properties and dust evolution
16:30-17:00 **Mathieu Compiègne**, The dust evolution at the interface between dense and diffuse media
17:00-17:30 *Coffee break*

Session: Dust emission in galaxies (I)

17:30-18:00 **Karl Gordon**, An overview of Spitzer observations of dust in galaxies
18:00-18:30 **George Bendo**, The SEDs of two nearby galaxies observed with SPITZER and JCMT
18:30-19:00 **General discussion**
20:00-22:00 *Dinner & Pub discussion*

Tuesday 15 May 2007

Session: Dust emission in galaxies (II)

09:00-09:30 **Cristina Popescu**, The dependence of PAH and dust emission SEDs of spiral galaxies on the intrinsic colour of emitted stellar light and disk opacity
09:30-10:00 **Suzanne Madden**, The Prospects of the Herschel Space Observatory for the Study of Gas and Dust in Galaxies
10:00-10:30 **Richard Tuffs**, The Space Infrared Telescope for Cosmology and Astrophysics (SPICA) and its potential for the investigation of dust emission in and around galaxies
10:30-11:00 *Coffee break*

- 11:00-11:30 **Frank Israel**, Dust and Molecules in Late type Galaxies
11:30-12:00 **Caterine Vlahakis**, The SCUBA Local Universe Galaxy Survey: dust along the Hubble sequence
12:00-12:30 **Marcel Clemens**, Metallicity gradients in spiral galaxies from sub-mm dust emission
12:30-13:00 **General discussion**
- 13:00-14:30 *Lunch break*
- 14:30-15:00 **Andreas Lundgren**, APEX - Atacama Pathfinder EXperiment
- Session: Dust and stellar evolution**
- 15:00-15:30 **Leslie Hunt**, Bulges and disks in spiral galaxies: clues for secular evolution?
15:30-16:00 **Michael Pohlen**, Galaxy Evolution: the shape of galactic disks
16:00-16:30 *Coffee break*
16:30-17:00 **Veronique Buat**, FIR and UV surveys from $z=0$ to 1. Do we see the same universe at both wavelength?
17:00-17:30 **Jorge Iglesias**, UV to IR SEDs of UV selected galaxies in the ELAIS fields: evolution of dust attenuation and star formation activity from $z=0.2$ to $z=0.7$
17:30-18:00 **Daniele Pierini**, The diversity of red disk-like galaxies at intermediate/high redshifts
18:00-18:30 **General discussion**
- 20:00-22:00 *Conference Dinner*

Wednesday 16 May 2007

- Session: Gas and dust in disks**
- 09:00-09:30 **Edvige Corbelli**, Dust and gas as tracers of star formation in M33
09:30-10:00 **Ute Lisenfeld**, CO and dust in galaxy collisions
10:00-10:30 **Edo Noordermeer**, The relation between gas, stars and dark matter in early type disk galaxies
- 10:30-11:00 *Coffee break*
- 11:00-11:30 **Diego Garcia Appadoo**, Properties of HI selected galaxies
11:30-12:00 **Elias Brinks**, A preview of THINGS: the HI Nearby Galaxy Survey
12:00-12:30 **Santiago Garcia Burillo**, Extragalactic Chemistry of Molecular Gas: revealing the imprint of dust grain chemistry near and far
12:30-13:00 **General discussion**
- 13:00-14:30 *Lunch break*

Session: Planning future collaborations

- 14:30-15:00 **Jonathan Davies**, Summary talk
- 15:00-16:00 **Brainstorming and plan for actions**
16:00-16:30 *Coffee break*
16:30-17:30 **Brainstorming and plan for actions**
- 20:00-22:00 *Dinner and pub discussion*

Thursday 17 May 2007

- 08:00 *Breakfast and departure*

Statistical information on participants

Age structure:

30-35: 9

35-40: 6

40-45: 2

45-50: 5

50-55: 7

Gender:

Males: 22

Females: 7

Country of affiliation:

Belgium: 1

Chile: 1

France: 4

Germany: 5

Greece: 3

Italy: 4

Netherlands: 2

Spain: 3

UK: 5

USA: 1

Final list of Participants

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