

## Giuliana Cosentino



### Title

The "Shocking" Interaction between Supernova Remnants and Molecular Clouds

### Abstract

Despite the importance of massive stars and star clusters for the energy content, stellar population and evolution of galaxies, the mechanism that ignites their formation in molecular clouds is still poorly addressed. Infrared Dark Clouds (IRDCs) are the likely precursors of massive stars. It has been suggested that IRDC formation and dynamical processing by multiple shock episodes triggered by bubbles, such as HII regions and Supernova Remnants (SNRs), can efficiently initiate star formation within these clouds. It is thus important to understand the conditions of density and temperature set by large-scale shocks in IRDCs to constrain the ignition of star formation in these objects. In this work, I will present the large scale shock triggered by the SNR W44 in the IRDC G034. I will show how the shock, probed by Silicon Monoxide (SiO) and observed with ALMA, enhances the density of the processed gas to values compatible with those required for massive star formation and has helped to shape the cloud. Thanks to the high resolution achieved by ALMA, the internal physical structure of the shock was resolved for the first time, providing a direct test to Magneto-Hydro-Dynamic (MHD) shock theories. Moved by these results, we have initiated the large single-dish observing program SHREC, aimed to observe SiO(2-1) emission in SNRs interacting with molecular clouds. During the talk, I will briefly introduce the aim and technical aspects of SHREC and present preliminary results obtained toward the SNRs IC443 and W41

# Giuliana Cosentino

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### PROFILE

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I am an Origins Fellow at Chalmers University of Technology, interested in understanding how large scale shock interactions may shape the stellar content of our and other galaxies. Among my research interests are the physical and chemical properties of Infrared Dark Clouds (IRDCs), the physics and chemistry of interstellar gas undergoing magneto-hydrodynamic (MHD) shocks and the physical processes that set the earliest phases of the formation of high-mass stars. During my career so far as a student and then postdoctoral fellow, I have been acquiring experience in both laboratory and observational research that I am able to perform in the most independent way. I am now in a position of leading large observational projects and international collaborations. I am extremely enthusiastic about my work and enjoy facing the many exciting challenges of frontier research.

### Work Experience

**Origins Fellow**                      **Chalmers University of Technology**                      1<sup>st</sup> Nov 2019 - to present date

### Education

**Ph.D.**                                      **University College of London**                      2<sup>nd</sup> Nov 2015 - 28<sup>th</sup> Oct 2019  
**European Southern Observatory**                      1<sup>st</sup> Sept 2018 - 31<sup>st</sup> Aug 2019

“Physical and Chemical processes in Cloud-Cloud Collisions: Star Formation in the Making”

**Master Degree**                      **Università degli Studi di Palermo**                      10<sup>th</sup> Oct 2013 - 28<sup>th</sup> Oct 2015  
“Interstellar Ice Analogues. The role of a silicate substrate in the UV irradiation of methanol ices”.  
*Grade: 110/110 cum laude*

*The Thesis was proposed for the Prize “Giuseppe Gambino”, that was not awarded that year.*

**Bachelor**                                      **Università degli Studi di Palermo**                      5<sup>th</sup> Oct 2009 - 23<sup>rd</sup> Oct 2013  
“Formation of Complex Organic molecules by irradiation of CO ices; interest from an astrophysical point of view”.  
*Grade: 110/110*

### Specialised Training

**9th IRAM Millimetre Interferometry School (FR)**                      10<sup>th</sup> -14<sup>th</sup> October 2016  
The school provided me specialised training on theory of millimetre interferometry and techniques of data calibration and imaging. The school was particularly focused on the use of NOEMA and ALMA. Theoretical sessions were accompanied by hands-on activities on real data sets.

**Astrochemistry: From Space to the Earth (FR)**                      29<sup>th</sup> Aug - 09<sup>th</sup> Sept 2016  
The school covered topics ranging from observational to theoretical and laboratory astronomy, with particular regard to methods of detection and analysis of interstellar molecules; basic astrochemical processes and modelling; interstellar chemistry and star formation; basics of laboratory experiments for astrochemistry and spectroscopy. Hands-on activities provided the opportunity to apply the acquired knowledges to real astronomical outstanding questions.

## **Interstellar Shock School (FR)**

22<sup>nd</sup> -27<sup>th</sup> March 2020 (postponed)

The school intended to provide and overview on the theory of magneto-hydrodynamic-shock in the ISM and to complement this with hands-on session focused on the use of state-of-the-art MHD shock codes. The school was postponed due to the COVID-19 pandemic and it will take place in 2021. My acceptance to the school is secured.

## **Supervising Experience**

<b>Laboratory Demonstrator</b>	Courses PHAS1240, PHAS1241 University College of London	26 <sup>th</sup> Sep 2016 - 30 <sup>th</sup> April 2018
<b>co-Supervisor date</b>	Ms. Negar Entekhabi, Chalmers Master Student	10 <sup>th</sup> Dec 2016 - to present
<b>Supervisor</b>	Ms. Theo O'Neill (UVa), Chalmers Astrophysics & Space Science Summer Research Fellows	18 <sup>th</sup> May 2019 - 25 <sup>th</sup> July 2019
<b>Supervisor</b>	Mr. Liam Walters(UVa), Chalmers Astrophysics & Space Science Summer Research Fellows	15 <sup>th</sup> May 2018 - 27 <sup>th</sup> July 2018

## **Organisation of International Conferences and Events**

**Local Organising Committee (LOC)** “Take a Closer Look: The innermost region of protoplanetary discs and its connection to the origin of planets”  
European Southern Observatory (15<sup>th</sup> -19<sup>th</sup> Oct 2018)

**Co-organiser** “Star & Planet Formation Seminar Series”  
European Southern Observatory (4<sup>th</sup> Jan 2019 to 31<sup>st</sup> Aug 2019 )

**Scientific Assistants** Period 103 Observing Programmes Committee  
European Southern Observatory (26<sup>th</sup> -28<sup>th</sup> Nov 2018)

## **Grants and Fundings**

2015-2018	IMPACT PhD Studentship	from University College of London
2015-2018	Perren PhD Studenship	from University College of London
2018-2019	ESO Studentship Program Europe	from European Southern Observatory
27/02-03/2017	Funding to Visit to the ARC Node in Manchester	from RadioNet
11-18/07/2017	Funding to Visit to the IRAM30m Telescope	from RadioNet

## **Programming Experience and Language Skills**

### **IT Skills**

**General** Latex, Microsoft Word, Excel, PowerPoint, Pages, Numbers, KeyNotes  
**Specialist** PHYTON, CASA, IDL , GILDAS software, dS9, SCOUSE, MHD\_VODE

The SCOUSE code is an IDL tool that I used to perform robust and systematic analysis of multiple the line profiles. MHD\_VODE is a fortran code that I used to obtain models of the kinematic structure and molecular abundances of gas processed by MHD shocks.

## **Language Skills**

Italian Native speaker  
English Advanced (6.5 IELTS certificate), lived in London, UK, from Nov 2015 to August 2018 and from September 2019 to October 2019.

## **Observing Experience**

**Instituto de Radioastronomia Millimetrica (IRAM30m).** I am able to independently prepare and perform observations using the 30m single-dish antenna located in pico Veleta (Spain). Having carried out several observing pools (both related to my projects and on behalf of other scientists) with this facility, I am now considered an expert observed and I am allowed to make use of the facility remotely.

**Arizona Radio Observatory (ARO).** I carried out observing runs with the 10-m Heinrich Hertz Submillimeter Telescope (SMT) at ARO. Observations were part of the SAMPLING large observing program. I am also the PI of a the large program SHREC, that use the 12 m antenna at ARO, KP12m. I have performed numerous remote observing run and I have had a on-site visit on May 20<sup>th</sup>-29<sup>th</sup> 2019.

## **Observing Proposals**

### **Selected Proposal as Principle Investigator**

- IRAM30m Project 005-17  
Widespread SiO Emission in IRDCs: Molecular Cloud Filament Forming via Cloud-Cloud Collision
- IRAM30m Project 041-18  
Widespread SiO Emission in the Filamentary Infrared Dark Cloud G034.77-00.55
- IRAM30m Project 028-20  
Understanding the initial conditions of massive star formation induced by cloud-cloud collisions.
- JCMT Project M18BP053  
Mapping Magnetic Field in Infrared dark Clouds
- KMOS Project 0102.C-0616(A)  
The Infrared dark Cloud G034.77-00.55: chronicle of the first fully resolved CJ-type shock
- APEX Project 0102.C-0616(B)  
The Infrared dark Cloud G034.77-00.55: chronicle of the first fully resolved CJ-type shock
- SMA Project 2018B-S038  
G034.77-00.55 and the first fully resolved CJ-type interstellar shock
- ARO Large Observing Program  
SHREC: SHock interactions between supernova REmnants and molecular Clouds
- ALMA Project 2019.1.00639.S  
The Infrared Dark Cloud G034.77-00.55 and the first fully resolved interstellar magnetised shock
- YEBES Project 20D007  
Supernova Remnants and Molecular Clouds: history of a shocking interaction
- YEBES Project 20B009  
The Shocking Relationship between Supernova Remnants and Molecular Clouds
- SOFIA Project 09\_100 (pending)  
The Infrared Dark Cloud G034.77-00.55: Magnetic field in large scale shock interactions

- SOFIA Project 09\_101 (pending)  
Large Scale Shock Interactions in Infrared Dark Clouds: tale of a forming cloud

### **Selected Proposal as Co-investigator**

- ALMA Project 2016.1.01363.S P.I. I. Jimenez-Serra  
Widespread SiO in IRDCs: Cloud-Cloud Collision Formation of Molecular Cloud Filaments?
- ALMA Project 2018.1.00850.S P.I. A.T. Barnes  
From Filaments to Cores: Dynamics in Infrared Dark Clouds
- NOEMA Project S18AA P.I. J.D. Henshaw  
Investigating the kinematic Imprint of an Interstellar Collision

### **Invited Contributions to Conferences and Lectures**

- *Widespread SiO emission in Infrared Dark Clouds as a probe of cloud-cloud collisions and other shock interactions*  
Centro de Astrobiologia (CAS/INTA)- 17<sup>th</sup> Feb 2019
- *Widespread SiO emission in Infrared Dark Clouds as a probe of cloud-cloud collisions and other shock interactions*  
Wine & Cheese Seminar - ESO - 17<sup>th</sup> July 2019
- *Widespread SiO emission in Infrared Dark Clouds as a probe of cloud-cloud collisions and other shock interactions*  
Chalmers Astrophysics Seminar - Chalmers - 6<sup>th</sup> Feb 2019
- *Widespread SiO Emission in a sample of IRDCs*  
Star & Planet Formation Seminar - ESO - 2<sup>nd</sup> Oct 2018
- *Probing Cloud-Cloud Collisions with Silicon Monoxide*  
UCL-UHC Star Formation Meeting - 11<sup>th</sup> May 2018
- *Widespread SiO emission in IRDCs ...with a sprinkle of Supernova Remnant*  
AstroLunch Talk - UCL - 16<sup>th</sup> Feb 2018
- *Widespread SiO and CH<sub>3</sub>OH emission in Filamentary Infrared Dark Clouds*  
Star Formation and ISM Meeting - Royal Astronomical Society - 16<sup>th</sup> Jan 2017

### **Contributions to International Conferences**

#### **Talks**

- *Widespread SiO emission in Infrared Dark Clouds as a probe of cloud-cloud collisions and other shock interactions*  
From Stars to Planets II - 17<sup>th</sup> June 2018
- *Widespread SiO and CH<sub>3</sub>OH emission in Filamentary Infrared Dark Clouds*  
Astrochemistry For All - 16<sup>th</sup> Jan 2018
- *Widespread SiO and CH<sub>3</sub>OH emission in IRDCs*  
Faraday Joint Interest Group Conference - 11<sup>th</sup> Apr 2017
- *SiO and CH<sub>3</sub>OH parsec-scale emission in Infrared Dark Clouds*  
Royal Society of Chemistry-Royal Astronomical Society Astrophysical Chemistry Meeting - 23<sup>rd</sup> May 2016

#### **Posters**

- *Interstellar Plunging Waves: The shock interaction between Supernova Remnants and Molecular Clouds* European Astronomical Society Annual Meeting (former EWASS) - 3<sup>rd</sup> July 2020
- *Widespread SiO and CH<sub>3</sub>OH emission in Filamentary Infrared Dark Clouds* Olympian Symposium - 28<sup>th</sup> May 2018
- *Widespread SiO and CH<sub>3</sub>OH emission in Filamentary Infrared Dark Clouds* Faraday Joint Interest Group Conference - 11<sup>th</sup> April 2017
- *SiO and CH<sub>3</sub>OH parsec-scale emission in Infrared Dark Clouds* Star Formation 2016 - Exeter University - 22<sup>nd</sup> August 2016