

"Formation and evolution of stars and planets: accretion, ejection, and variability" (PID2023-146295NB-I00)

Summary of the project: Star formation is a fundamental process in nature by which cold interstellar clouds of gas and dust are transformed into hot, dense objects such as stars. During this process, driven primarily by gravity, an accretion disk is formed around the protostar. Through the disk, accretion and ejection of material maintain a symbiotic relationship, since the disk helps to eject excess material as a high-velocity bipolar jet, and thus extracting the excess angular momentum, so that the star can continue to grow and gain mass. Moreover, the evolution of this disk (the protoplanetary disk) can give rise to a planetary system. Emerging evidence indicates that mass accretion, necessary for the formation of a star and its planetary system, is not a continuous and stable process but undergoes episodes with large increases in accretion and ejected matter, even in the earliest phases of protostellar evolution. In this project we plan to use both observational (mainly observations using large facilities at radio and infrared wavelengths) and modeling tools (mainly radiative transfer and hydrodynamical models of planetary disks) to study in detail the star and planet formation process. Notably, the early and late stages of stellar evolution show striking similarities in their characteristics, despite being separated by billions of years. Both young and old stars are enshrouded by thick envelopes of gas and dust, rendering them invisible at optical wavelengths for long periods of time. Planetary nebulae (PNe) represent the last evolutionary stages of low- and intermediate mass stars, before the white dwarf phase. Therefore, most stars in the Universe, including our Sun, will at some point become a PN. Their immediate progenitors are stars in the Asymptotic Giant Branch (AGB), when a dense, expanding circumstellar structure is created. The ejection of collimated, high-velocity jets, as well as the presence of circumstellar structures and accretion disks, and even substellar objects and planets, are all key elements in these last evolutionary phases. Moreover, some of our most recent results, show new aspects of variability, not only in the strength of the emission but also in the kinematics. These parallelisms in young and old stars strongly indicate that similar physical processes are at work at both extremes of stellar evolution, and allow us to study them with similar observational and theoretical tools.

Webpage: <https://spfe.es/en/> (English), <https://spfe.es/es/> (Spanish)

Principal Investigator 1

Name: Guillem Josep Anglada Pons

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Degree: PhD in Physical Sciences, Univ Barcelona (1989).

Current position: Senior Scientific Researcher (Investigador Científico) at Instituto de Astrofísica de Andalucía (IAA-CSIC), since 2005.

Previous positions: Interim Professor (Profesor titular interino) Univ of Barcelona (1990-1996), Senior Researcher B (Investigador Titular B) Institute of Astronomy UNAM (1996-1997), Senior Scientist (Científico Titular) IAA-CSIC (1997-2005), Visiting Scientist Harvard-Smithsonian CfA (2001-2002).

Lines of research: Radio astronomy of interstellar medium; star and planet formation. Pioneering work on imaging signatures of cloud collapse, protoplanetary disks at long radio wavelengths, discovery of water in planetary nebulae, first mm detection of Proxima Cen, discovery of synchrotron radio emission in protostellar jets. Leading expert in protostellar radio jets, with his reviews (e.g., Anglada 1996, ASP Conf Ser,

93, 3; Anglada et al. 2018, A&A Rev, 26, 3) being the main references to establish their properties and nature, as well as the procedures to characterize them.

Publications: 154 refereed papers (including 3 Nature, 2 Science, 1 Science Adv), 11 reviews, 6 book chapters, 3 university textbooks, >100 publications in conference proceedings and 18 outreach articles. Outstanding participation (invited speaker, session chair or SOC member) in >30 conferences.

Research impact: >6500 citations, >1250 as first author. $h = 45$. The published results have been highlighted in numerous national and international press releases and have received outstanding comments in Nature, Science and Nature Astronomy.

Academic positions and R&D management: Member of the Faculty of Physics Council of the Univ Barcelona (1991-1995), Chair of the Radio Astronomy and Galactic Structure Department of the IAA-CSIC (2002-2005), Member of the IAA-CSIC Council (2002-2009), Science ViceDirector of the IAA-CSIC (2005-2009), ViceSecretary (2006) and Secretary (2007-2009) of the National Astronomy Commission, Member of the Canarian Observatories International Scientific Committee (2007-2009), Member of the Coordination Committee of the Spanish node of the International Year of Astronomy (2007-2009), Director of the IAA-CSIC (Jan-May 2009), Member of the "Cradle of Life" working group of SKA (2017-), Head of the "Physics of the Interstellar Medium" group of the CSIC.

Academic distinctions: CIRIT of Catalonia Award (1988), Extraordinary Doctorate Award Univ Barcelona (1992), Henri Chrétien Award American Astronomical Society (1992), Patrimonial Chair of Excellence CONACYT Mexico (1996).

Academic Incentives: 6 research Sexennia and 6 Quinquennia.

Evaluation and refereeing: Referee for the main journals of the field (ApJ, ApJL, AJ, A&A, PASJ, RevMex Física, RevMexA&A, MNRAS, Nature Comm, Nature Astron) and evaluator for CONAyT (Mexico), Fondecyt (Chile), ANEP, TAC Observatorios de Canarias, NATO, MERLIN interferometer (UK), Job selection committees of several national and international academic institutions (including Technologist positions), AGAUR (Generalitat Catalunya), Univ of Granada, RyC Program, ANR (France), NRAO (USA), ALMA.

Training of personnel: 6 PhD theses (+1 in progress) and 8 BSc/MSc theses directed. Responsible for 7 postdoctoral contracts, 5 predoctoral fellowships, and 3 research scholarships. The book "Introducción a la física del medio interestelar" (Estalella and Anglada 1996, 1997, 1999, 2000, 2008) is a textbook in >7 Spanish-speaking universities.

Principal Investigator 2

Name: Mayra Carolina Osorio Gutiérrez

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Degree: PhD Physical Sciences, Universidad Autónoma de México (2000).

Current position: Scientific staff (Doctora Contratada Fija), pending to take up a position as Senior Scientist

Previous positions: Postdoctoral Fellowship at Harvard-Smithsonian CfA, USA (Jan 2001-Oct 2002), Postdoctoral Fellowship at IAA-CSIC (includes periods of sick leave due to pregnancy), Spain (2002-2006), Fixed-term postdoctoral contract at IAA-CSIC (includes maternity leave), Spain (2006-2011), Non-permanent indefinite postdoctoral contract at IAA-CSIC, Spain (2011-2021).

Academic positions and R&D management: Member of the "Woman and Astronomy" committee of the SEA (2016-2021), group of CSIC experts to elaborate a Proposal of

"Scientific Challenges in Strategic Themes (2020), Board of IAA (2021-). Chair of the first symposium on Star and Planet formation organized within the framework of the SEA2024.

Academic distinctions: "Weizmann Prize" of the Mexican Academy of Sciences to the best PhD thesis in Exact Sciences (2003); IAU "Peter Gruber Fellowship Award" (2003); R3 certificate in the first call (2022), which recognizes the quality of the researcher in compliance with the European Researcher Profile.

Evaluation and refereeing: Referee for A&A, MNRAS, ApJ journals. Evaluator of FONCyT (Argentina), CONICYT (Chile), ConTex (Texas-Mexico) grants, UNAM (Mexico) tenure track position, OPTICON and ALMA observatory proposals. Member of master/PhD theses committees at different universities (2006-). Member of the evaluation committee of the Award for the Best Theses in Astronomy in Mexico (2013-2016).

Publications: 70 papers in refereed journals (including 1 in Science), 3 reviews, 4 book chapters, >90 conference proceedings, 18 outreach articles. Outstanding participation (invited speaker or SOC member) in 21 conferences.

Research impact: >3000 citations (>350 to first-author papers). $h = 30$. Published results highlighted in national and international press releases.

Lines of research: Physics of the interstellar medium; Star and planet formation; Protoplanetary disks; Jets and outflows; Radiative Transfer; Modeling of protostars and accretion disks; Radio astronomy. Leading expert in Protoplanetary disks and radiative transfer models.

Training of research personnel: Direction of 1 PhD thesis (+2 in progress), 6 Master theses, 3 Bachelor thesis, 5 internship students. My former PhD student, E. Macías (2016), currently holds a tenured position at ESO-Germany. Lecturer at international advanced schools for graduate students and young postdocs (Harvard Univ. 2002; Univ. Barcelona 2005, 2023; Univ. Granada 2023, 2024; ICE-CSIC 2018, 2023).

Outreach: Teaching at undergraduate, graduate and high school level. Wide outreach in Astronomy: articles in the press (e.g., for the section "Ellas responden" of El País newspaper); interviews in the media to make visible the role of women in science; organizer of the successful program "Chat with a Woman Astronomer"; numerous talks, videos and activities in schools and cultural centers to awaken the interest of girls in astronomy (e.g., through the IAU NameExoWorlds 2022 contest); member of the evaluation committee of the drawing and poetry contests organized by the SEA in the International Day of Women and Girls in Science; teacher training courses (e.g., of the European Space Agency); outreach conferences at prestigious institutions (e.g., at the "Colegio Nacional de México", the Univ. of Puerto Rico).