**Dr. Carlo Janna, PhD - Curriculum Vitae**

Carlo Janna (CJ) was born in Dolo (VE), Italy, on November 14th, 1976.

In 1996 he got the high school diploma at the Liceo Classico Statale "Eugenio Montale" in San Dona' di Piave (VE).

After entering the Faculty of Engineering at the University of Padova (Italy), he graduated in **Civil Engineering**, Structural qualification, on October 23th, 2003 with 109 points over 110, defending a thesis entitled: *Elastic-Plastic behaviour with damage of thin shells undergoing large displacements and rotations* with Prof. Carmelo Majorana, PE, as advisor. He was appointed a **Professional Engineer** on June 2004.

On January 2005 he started his PhD course with specialization in Enviromental and Civil Engineering Sciences at the University of Padova (Italy) and on May 27rd, 2008, he got his **PhD degree** defending a thesis entitled: *Numerical modeling of the mechanical behaviour of regional faults in the geological sequestration of anthropogenic $CO_2$ sequestration* with Prof. Giuseppe Gambolati, PE (University of Padova) and Massimiliano Ferronato, PhD (University of Padova) as advisors. During his PhD program he joined for four months the research team of Tony Settari at the department of "Chemical and Petroleum Engineering" at the University of Calgary (Canada) working on multilevel incomplete factorization for geomechanical problems at regional scale.

From January 2008 to November 2011 he worked as **Post-Doc** at the Department of Mathematical Methods and Models for Scientific Application at the University of Padova.

Since December 2011 he is **Assistant Professor** at the Department ICEA at the University of Padova.
In October 2014 he received the national scientific qualification (ASN) to become **Associate Professor**.
In August 2017 he received the national scientific qualification (ASN) to become **Full Professor**.

**Scientific activity**

The main scientific interests concern on one hand the mathematical and numerical modeling of the mechanics of porous media in both saturated and unsaturated conditions with specific applications in subsurface hydrology and petroleum industry, on the other the numerical linear algebra. His main activity is the development and implementation of numerical models based on the Finite Element method for the simulation of subsurface coupled and uncoupled geomechanical and fluid dynamical processes in the exploitation of deep aquifer or reservoir resources. As to the linear algebra, Carlo Janna studies and develops numerical techniques for the solution of large sparse linear systems and eigenproblems and more specifically iterative methods and preconditioners. For sequential computers, he studied and developed several ad hoc preconditioners for the solution to specific problems arising in subsurface simulations. In particular he is carrying out the following research themes:

- Theoretical study, development and implementation of "Constraint"preconditioners obtained

by combining ILU and AINV preconditioners for the solution of ill-conditioned linear systems arising in contact mechanics problems;

- Theoretical study, development and implementation of "Breakdown-free" multilevel preconditioners based on incomplete factorization with "Diagonal Shift" and second order correction for the efficient solution of ill-conditioned linear systems arising in the geomechanical modeling of faulted rocks;
- Numerical study and experimentation of preconditioner update techniques for the parallel solution of shifted linear systems arising in transient problems of flow in a highly heterogeneous medium
- Theoretical study, development and implementation of hybrid preconditioners coupling FSAI and Incomplete Factorization on massively parallel computers;
- Use of "Domain Decomposition" techniques and ordering strategies on hybrid FSAI-ILU preconditioners to improve their parallel performance on HPC systems;
- Theoretical study, development and implementation of iterative methods coupled with hybrid preconditioners in the solution of eigenvalue problem on parallel computers;
- Theoretical study, development and implementation of parallel "Constraint" preconditioners for fully coupled poro-elastic problems;
- Development and implementation of new algorithms for the computation of FSAI preconditioenrs on the new Graphical Proccessing Unit (GPU) hardware;
- Theoretical study, development and implementation of adaptive AMG preconditioners for HPC systems;
- Theoretical study, development and implementation of Interface Elements for the simulation of mechanical discontinuities within faulted porous media;
- Theoretical study, development and implementation of non-linear constitutive laws for the numerical simulation of porous materials;
- Use of fully coupled and uncoupled poro-elastic models on problems related to the development of natural resources in deep auifers or reservoirs and to the re-injection of $CO_2$ or gas underground;
- Complex geomechanical models calibration through the use of Data Assimilation and Optimization techniques.

From 2010 to 2013, Carlo Janna joined the **HPC** research projects **PARPSEA** (PARallel Preconditioners for large Size Engineering Applications), **SCALPREC** (SCALable PREConditioners), **OPTIDAS** (OPTImization and Data ASSimilation), **SPREAD** (Scalable PREconditioners for Advanced Discretizations), **PARPREC** (PARallel PREConditioners) studying and developing new preconditioners for massively parallel computers.

He co-advised the following PhD Thesis:

"A 3D model for two-phase flow and geomechanical coupling in petroleum reservoirs" by Hermínio Tasinafo Honório at the Federal University of Santa Catarina, Brazil, 2017.

"Numerical models for the large-scale simulation of fault and fracture mechanics" by Andrea Franceschini at the University of Padova, Italy, 2018.

"Robust and Scalable Algorithms for the Solution of Real-world sparse linear systems" by Victor Antonio Paludetto Magri at the University of Padova, Italy, 2018.

**International Collaborations**

During his research activity he has carried out some collaborations with foreign researchers. In May-September 2007 he joined the research group headed by Tony Settari at the "Department of Chemical and Petroleum Engineering" of the University of Calgary. In September 2012 he worked at the IBM Thomas J. Watson research center in Yorktown, USA, on a project funded by the company ENI for the development of numerical methods for the sedimentary basin simulation. From 2014 to 2017 he was involved in the "Science without Borders" program funded by the Brazilian CNPq. Within this program CJ visited several times the SINMEC laboratory in the mechanical engineering department of the University of Santa Catarina, Florianopolis, giving classes and co-advising master and PhD students. In 2017 and 2018, CJ was hosted several times in the headquarters of Simulia Corp. in Johston, RI (US) joining the solver group of the company to collaborate in the development of the parallel linear solver of the FEM commercial code ABAQUS.

**Reviewer and Editor activity**

He carries out the reviewer activity for the following journals: Advances in Engineering Software, Applied Mathematical Modeling, Applied Numerical Mathematics, BIT Numerical Mathematics, International Journal of Rock Mechanics and Mining Sciences, Journal of Applied Mathematics, Mathematical Problems in Engineering, SIAM Journal on Scientific Computing. He is currently in the Editorial board of Advances in Engineering Software and of the International Conference on Parallel, Distributed, Grid and Cloud Computing for Engineering.

**Consultancy and professional activity**

As a post-doc or researcher, he used the results of his research in a number of consultancy projects on behalf of the Univeristy of Padova for private companies as ENI, ENEL, SNAM Progetti and STOGIT, on the following topics:

- Development of a numerical library for the parallel solution to linear systems of equations;
- Development of mathematical models for subsidence simulation and environmental risk estimation connected to the exploitation of hydrocarbon resources;
- Development of mathematical models for subsidence simulation and environmental risk estimation connected to the injection of fluids underground;
- Software development to simulate the stress state evolution in a sedimentary basin generation.

In 2011 he co-founded the M3E company, a spin-off of the University of Padova, that he currently leads as CEO (https://www.m3eweb.it). The mission of the company is the technology transfer from the academic research to industry. Over years M3E has provided services to several private customers such as ENI, GasPlus, Edison, SAIPEM and Simulia Corp, on the following topics:

- Development of algorithms for the 3D shape reconstruction of long cables from optical fiber

strain measurements.
- Development of mathematical models for subsidence simulation and environmental risk estimation connected to the exploitation of hydrocarbon resources;
- Development of linear solvers for massively parallel simulation on HPC systems;

CJ authored the M3E_linsol library for the solution of linear systems on high performance computers that is currently installed in Tempra-HR, a ENI proprietary software for basin simulation on massively parallel computers.

**Minisymposia organized**

- "Iterative Solvers for Environmental Simulations" in collaboration with Massimiliano Ferronato, Mario Putti and Carol S. Woodward at the "SIAM Conference on Computational and Mathematical Issues in the Geosciences", Long Beach, California, 21-24 Marzo, 2011;
- "Efficient preconditioners for real world applications" in collaboration with Luca Bergamaschi and Massimiliano Ferronato at the "SIAM Conference on Applied Linear Algebra", Valencia, Spagna, 18-22 Giugno 2012;
- "Preconditioning Techniques for Sparse Linear Systems on GPUs" in collaboration with Massimiliano Ferronato at the "SIAM Conference of Parallel Processing for Scientific Computing", Portland, Oregon, February 18-21, 2014;
- "Preconditioning techniques for non-symmetric or symmetric indefinite matrices" in collaboration with Massimiliano Ferronato at the "SIAM Conference on Applied Linear Algebra", Atlanta, Georgia, October 20-26, 2015;
- "Preconditioners for ill-conditioned linear systems in large scale scientific computing" in collaboration with Luca Bergamaschi and Massimiliano Ferronato at the "SIAM Conference on Applied Linear Algebra", Honk Kong, Georgia, October 20-26, 2015;

**Keynote Speaker**

"3rd International Conference on Parallel, Distributed, Grid and Cloud Computing for Engineering", Pecs, Ungheria, 25-27 marzo 2013, with the talk "Approximate inverse preconditioning for the solution to large sparse linear systems".

**Software**

He is author of two publicly available numerical libraries for the parallel solution of linear system of equations:

- BFSAI-IC OpenMP Implementation at http://www.dmsa.unipd.it/~ferronat/software.html
- FSAIPACK at http://www.dmsa.unipd.it/~janna/software.html