UNIVERSITÀ DEGLI STUDI DI PADOVA

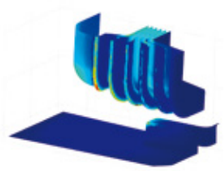
DIPARTIMENTO DI INGEGNERIA INDUSTRIALE

DII NFORMA

DICEMBRE 2018
ANNO 4

NEWSLETTER DEL DIPARTIMENTO DI INGEGNERIA INDUSTRIALE
DELL'UNIVERSITÀ DEGLI STUDI DI PADOVA

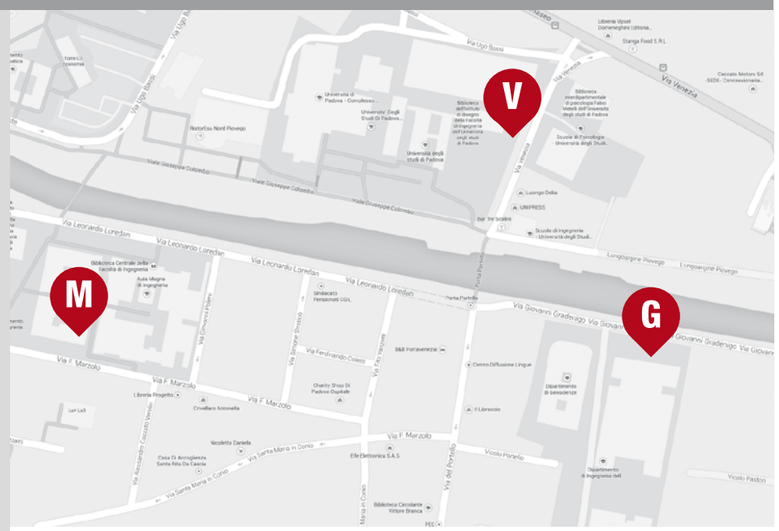
Cover story



Distribuzione del campo elettrico nell'acceleratore di MITICA.
L'immagine mostra l'intensità del campo elettrico sulla superficie dell'acceleratore di MITICA (Megavolt ITER Injector and Concept Advancement), il prototipo in scala reale dell'iniettore di neutri del reattore a fusione sperimentale ITER, ovvero il sistema di riscaldamento per portare il plasma nelle condizioni di ignizione delle reazioni termonucleari. Questo sistema si basa sull'accelerazione di ioni negativi a 1 MeV e sulla loro successiva neutralizzazione. Il progetto di tale complesso sistema in altissima tensione (1MV) in ultra alto vuoto costituisce una nuova grande sfida ingegneristica che ha spinto il gruppo di ricerca sulla Fusione di Padova a sviluppare ed utilizzare nuovi metodi e strumenti di simulazione, tra cui il Voltage Holding Prediction Model (VHPM), un innovativo modello predittivo della tenuta di tensione di complessi sistemi elettrostatici isolati in vuoto, successivamente applicato anche per la caratterizzazione di dispositivi di rilevante interesse industriale.

Ing. Nicolò Marconato
Nato a Venezia, il 05/01/1983. Ricercatore a tempo determinato di tipo A presso il dipartimento di Ingegneria Industriale. Dopo aver conseguito la laurea magistrale in Ingegneria Elettrotecnica nel luglio 2008 presso l'Università di Padova, ha iniziato la sua attività di ricerca nel campo della fusione termonucleare controllata presso il Consorzio RFX, dapprima come dottorando e successivamente come ricercatore. I suoi interessi di ricerca riguardano principalmente l'elettrotecnica computazionale, lo sviluppo di sistemi elettromagnetici complessi e i sistemi di diagnostica magnetica e controllo dell'equilibrio dei plasmi da fusione.

SEDI



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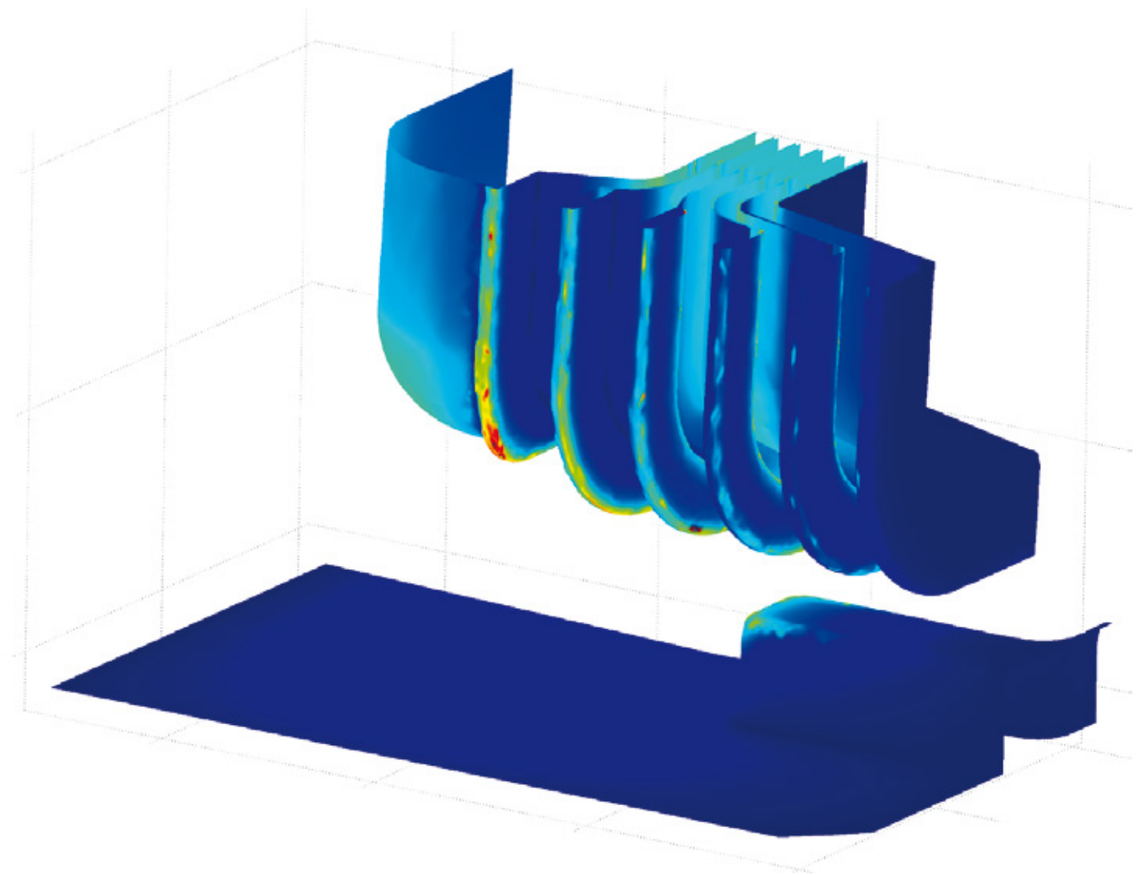
UNIVERSITÀ DEGLI STUDI DI PADOVA

DIPARTIMENTO DI INGEGNERIA INDUSTRIALE



COPERTINA

Distribuzione del campo elettrico nell'acceleratore di MITICA.

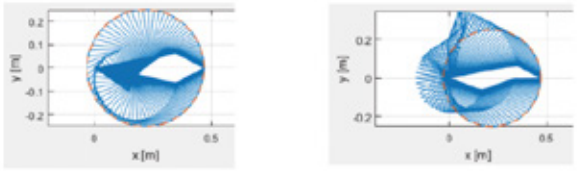
PAGINA

DIPARTIMENTO DI INGEGNERIA INDUSTRIALE

Optimal motion planning of redundant robot manipulators

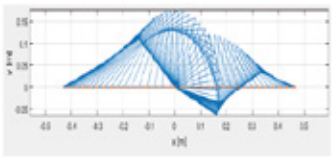
Increasing energy prices and growing environmental awareness have driven engineers and scientists to find new solutions for reducing energy consumption in robotic manufacturing. In addition, the spread of 7-DOF collaborative robots in industry gives a real chance to minimize the required mechanical energy and related costs by exploiting their redundancy through new motion planning methods.
The aim of this research line is to develop new motion planning methods for minimizing the energy consumption of redundant robot manipulators, with a focus on trajectory tracking tasks. Typical economically important industrial applications are for example robotic painting, sand blasting, and machining.
The proposed research line is split in the following interconnected research topics:

1) Energy-efficient motion through prediction of minimum energy direction: ***totally new solution developed , suitable for real-time implementation, based on a predictive kinematic control algorithm that computes the direction of minimum end-effector error and kinetic energy integral over a set of future exploration points.***



Stroboscopic views of robot motion: preliminary investigations showed 33% energy savings of proposed algorithm (left) wrt minimum velocities solution (right) for a circular robot trajectory.

2) Global optimum method: ***the proposed method is based on the generation of a set of convenient robot trajectories to be used as input for a multi start algorithm, which significantly reduces the complexity and computational burden of optimal control and genetic algorithms. The method is developed for minimizing kinetic energy, but can be extended for a generic cost function.***

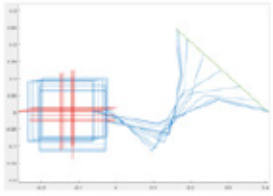


Preliminary investigations showed up to 57% energy savings wrt pseudoinverse solution using a free robot initial configuration (top). Validation will be carried out in real industrial test cases using the latest generation collaborative robots (right).

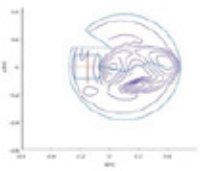
ABB YuMi

KUKA LBR iiwa

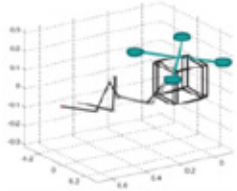
3) Extended reactionless workspace of a free-flying robot: ***the zero-reaction workspace of a redundant manipulator mounted on a moving base is significantly extended through the use of a reaction wheel. Zero reactions on the base correspond to minimum energy consumption to stabilize the moving base and increased autonomy.***



Stroboscopic view of robot motion (with reaction wheel).



Extended reactionless workspace with iso-manipulability curves.



LTU Aerobot. Potential applications/validation scenarios:
- Service robotics (e.g. search and rescue, extreme environment, etc.)
- Industry (assembly, logistics, etc.)

Robotica e Industria 4.0

Robotics and Industry 4.0

DII research group

Machine Mechanics

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The research activity is carried out in collaboration with University of Strathclyde, Glasgow (UK)

Main research topics:

- Redundancy and optimization in robotics
- Global vs local optimization
- Energy-efficient motion planning
- Trajectory optimization
- Kinematic control
- Reaction control
- Robot workspace analysis
- Manipulability analysis
- Industry 4.0
- Collaborative robots
- Aerial manipulators

Materiali funzionali e prototipi

Functional materials and prototypes

DII research group

PEG: Polymer Engineering Group

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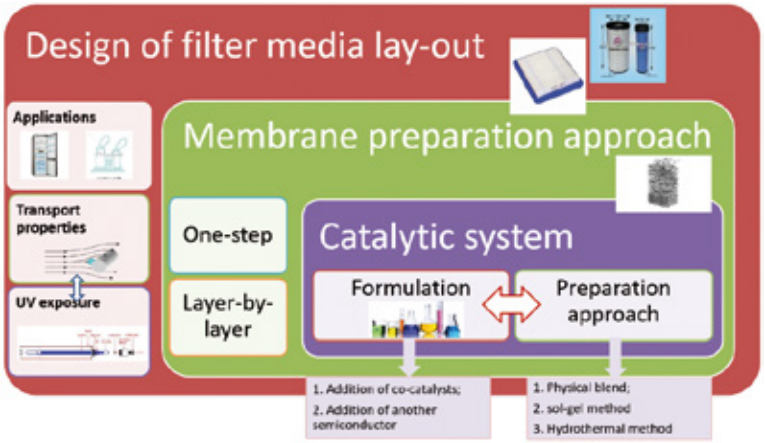
The research activity is carried out in collaboration with: Prof. M. Modesti and Prof. A. Lorenzetti at the Polymer Engineering Group

Main research topics:

- Nanostructured Media:
  Air purification: PCO processes for VOCs abatement; Technologies and Implemented strategies for enhancing the photocatalytic performance; CO2 capture;
- DoE (RSM, Process optimization)
- Functional materials (Magnesium borate, Silicon oxycarbide ceramics…)
- Electrospun scaffolds for biomedical applications
- High performance nanocomposites (both thermoplastic and thermoset)
- Polymers fire behaviour and thermal resistance

Strategies for enhancing the performance of TiO_2 based nanostructured membranes for VOCs abatement

Investigation of indoor and outdoor air quality has become, in the last decade, an important scientific concern. Volatile Organic Compounds (VOCs) represent an heterogeneous group of organic chemicals strongly present in those industrial activities related to the use of solvents, such as printing, spray painting, coil coating, wood treatment etc. Due to the pressing need for actions to improve air quality and protect people and ecosystems from the threats posed by air pollution, scientists spend a lot of efforts trying to investigate the health effects of pollutants, as well as the potential strategies for their control and abatement.



Since the beginning of this research work, we dealt with photo-oxidation of methanol in gas phase, studying different nonwoven mats assemblies6, and eventually the effect of a co-catalyst, based alternatively on Graphene oxide (GO), reduced graphene oxide (rGO) and graphene (G). What appears clear is how different intervention strategies can exist in the case of photocatalytic processes carried out by electrospun nanostructured materials. First, it is possible to act on the catalytic system in terms of formulation (addition of a co-catalyst or addition of another semiconductor) and preparation approach (physical blend, sol-gel method, hydrothermal method). Subsequently, it is possible to deal with the membrane preparation approach and finally with the design of the active filter media lay-out, including the UV exposure and the transport properties of the mixture to be treated. According to this, the principal goal of the research is the design an active filter media with sufficient photocatalytic activity and adequate physicochemical stability. The results obtained varying the formulation of the photo-catalytic systems are reported here with respect to photo-oxidation in gas-phase of 1600ppm of acetaldehyde.

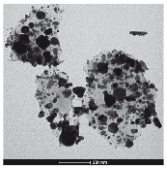
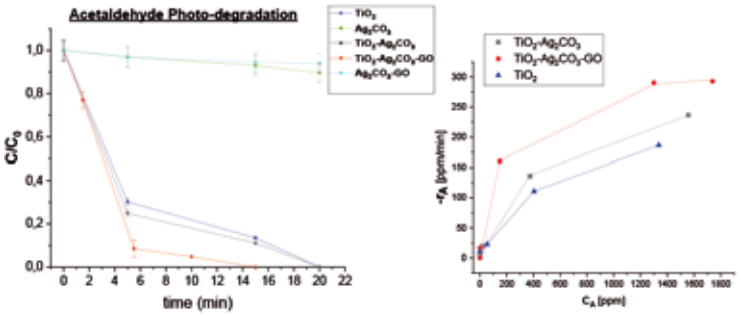


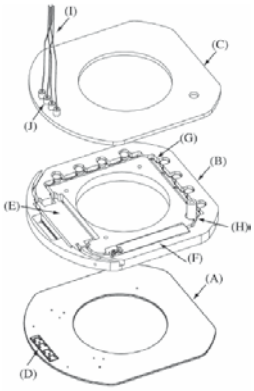
Figure. Acetaldehyde removal vs time (a) and reaction rate vs concentration (b) for all the photocatalytic systems.



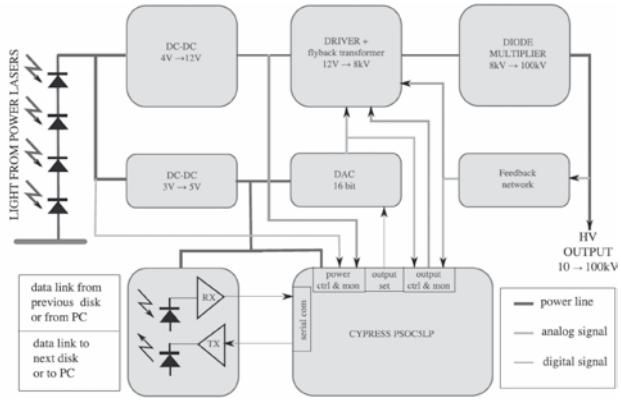
(a) (b)

Realization of a high voltage generator by series connection of floating modules

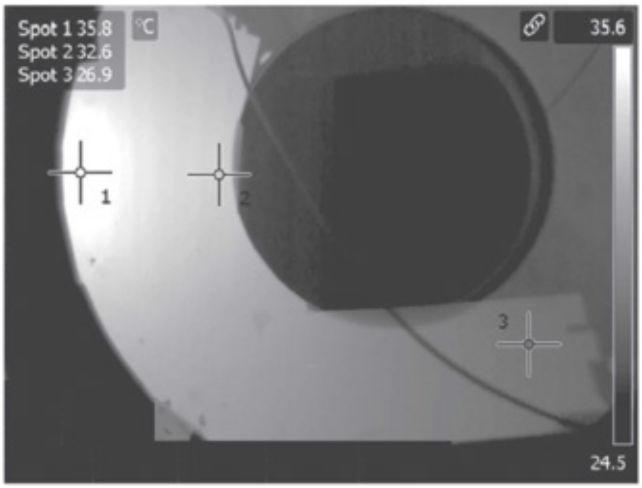
High Voltage (HV) generators, which are able to provide current up to 100 μA, can be used in a variety of applications, including the production of ion beams for proton-induced X-ray emission (PIXE) and ion implantation among others. The usual Van de Graaff high voltage generation scheme has the drawback of having moving parts. The requirement of avoiding this drawback led to the development of capacitively coupled Cockcroft-Walton high voltage power supplies that are more reliable and compact devices, being fully static objects. They are now the state-of-the art generators in the megavolt (MV) range. The HV is normally generated on two terminals in a single step by means of electrostatic belts (in a Van de Graaff generator) or by HV multiplication (in a Cockcroft-Walton generator) starting from a single low voltage, high power source. This research deals with the actual realization of a high voltage generator prototype, based on a series connection of lower voltage modules, whose feasibility was originally argued in previous researches. The power source is a laser system providing the power to the high voltage multiplier through light conversion by the photovoltaic effect on high efficiency solar cells. This wireless powering scheme allows the development of relatively low voltage floating modules which could be connected in series in order to provide higher voltages. The advantage of a modular approach with respect to current systems in the MV range is clearly in the maintenance since any intervention requires simply the replacement of the broken module. Furthermore the proposed technique allows upgrades of the system by simply adding more modules and replacing, if needed, its containment tank.



Exploded view of a 100 kV high voltage module



Block diagram of the setup and control electronics



Thermographic image of the temperature distribution on the surface of the back side of the radiator disc. The power cells are placed at spot #1 position on the front side.

Ingegneria dei sistemi elettrici

Electric Systems

DII research group

High Voltage Group

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This research activity is carried out in collaboration with:
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DIPARTIMENTO DI FISICA E ASTRONOMIA "GALILEO GALILEI"

INFN Laboratori Nazionali di Legnaro

Main research topics:

- Metrology of high impulse voltages; Long distance sparks in air and influence of waveshape;
- Partial discharges. Metrology and pattern analysis in relation to component defects;
- Interturn stress analysis for MV rotating machines. Measurement of fast transients.

Ingegneria dei sistemi elettrici

Electric Systems

DII research group

Power System Group

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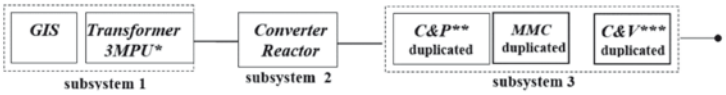
Roberto Benato, Professor at the Department of Industrial Engineering, Padova.
Evaristo Di Bartolomeo, Mattia Pazienza, Massimo Rebolini, Luciano Minto, Luca Guizzo, with Terna Rete Italia, Roma.

Main research topics:

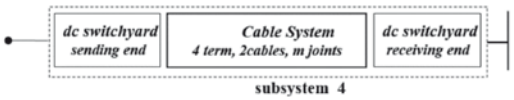
- Large-scale energy storage in the network;
- EHV/HV dc and ac innovative transmission lines e.g. insulated cables and gas insulated lines;
- Synergy between railway and highway infrastructures and insulated cables;
- Multiconductor cell analysis (MCA) of asymmetric systems by means of self-implemented matrix procedures (insulated cables with screens and armours, gas insulated lines with enclosures, overhead lines with one or more earth wires);
- Availability assessment of whole HVDC-VSC links
- Sinergy between insulated cable power transmission systems and transport infrastructures;
- Smart grids: the operation and control of active networks;
- Voltage regulation in the distribution network with high penetration of distributed generation.

High Voltage Direct Current electric lines in the transmission grids of the future

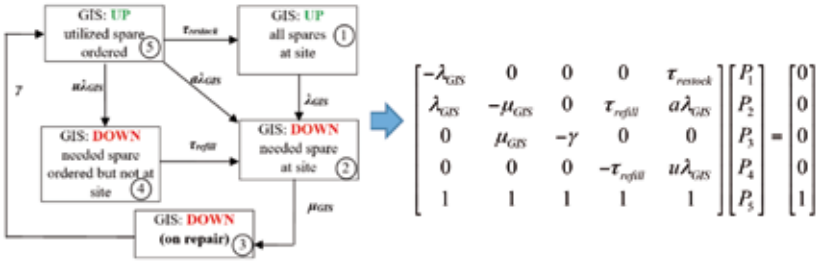
HVDC-VSC transmission gains growing interest for its capability of providing multiple vital services within electrical power networks in the form of supply of reactive power and other ancillary services, which can be secured even if an outage interrupts the transmission function itself. This research focuses on the development of analytical methods for availability/unavailability assessment of HVDC-VSC point-to-point connections and on the study of the compatibility between HVDC systems and transport infrastructures. The Key reliability features of modular multilevel converters (MMC) are taken into account by means of closed-form reliability equations, and combined with the Markov state-space models of each component of the HVDC system in order to asses the whole system availability. The possibility of correctly estimating the availability of HVDC systems is becoming more and more important, especially when highway and railway infrastructures (planned or existing) are exploited in order to install HVDC insulated cables. In fact, different services hosted into the same infrastructures require accurate availability analyses to efficiently manage the structure itself. A practical application of these concepts is represented by the ±320 kV HVDC VSC interconnection between France and Italy named "Piedmont-Savoy" which will constitute a further strengthening of the Pan-European grid. This cross-border interconnection will be mostly hosted on the existing highway infrastructures.



Border interconnection will be mostly hosted on the existing highway infrastructures



Block diagram of a whole HVDC-VSC symmetrical monopole



Example of Markov state-space model approach: HVDC GIS subsystem and the related probabilistic matrix

Symmetrical monopole component	*Availability (steady-state)*	*Unavailability*	*Mean Outage Time [hrs/year]*
GIS	0.9997	$2.9303 \cdot 10^{-4}$	2.57
Transformer	0.9996	$3.1650 \cdot 10^{-4}$	2.77
Converter Reactor	0.9971	0.0029	25.4
Converter (incl. C&V)	0.9986	0.0014	12
Cable Circuit (105 km)	0.9700	0.02991	262.01
dc Switchyard (Swy)	0.9993	0.0007	6.13
Cable Ct.+ 2 terminals	0.9687	0.03131	274.28
Whole Link	**0.9666**	**0.0334**	**292.58**

Availability assessment of the whole HVDC link

HVDC power cables installed in highway infrastructure in the future Piedmont-Savoy intertie

Voltage Holding Prediction Model (VHPM): a novel technique for breakdown probability evaluation in complex medium and high voltage devices in vacuum

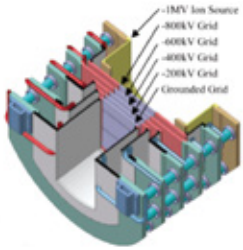
The Voltage Holding Prediction Model (VHPM) is aimed at improving the design of high-vacuum complex electrostatic devices, extensively used in many research and industrial areas, with respect to the simple analysis of the electric field distribution. This is done by the adoption of a probabilistic approach, combined to a more advanced breakdown physical model, that defines a new breakdown variable W, depending upon electric field and voltage applied.

It was developed for the design of the electrostatic accelerator of the Neutral Beam Injector for the International Thermonuclear Experimental Reactor (ITER), with the challenging requirement of withstand 1 MV in a very tight high vacuum environment, and at a later time adopted for the optimization of Siemens medium voltage Vacuum Circuit Breakers (VCB). The VHPM has the twofold advantage of allowing on one hand to identify the most critical regions of the considered geometry, which can be more prone to breakdowns, on the basis of the above mentioned criterion, and on the other hand to identify an univocal probabilistic relation with respect to the voltage applied. It is implemented in the numerical code CAFE, that uses two complementary electrostatics geometric formulations, allowing the convergence to a very precise solution of the electric field distribution, and include a suitable post processing tool for the efficient tracing of charged particle trajectories, as required by the probabilistic model adopted. This last one is assumed to follow a two-parameters Weibull distribution, depending on the experimentally obtained Weibull parameters m and W0 and on the cumulative contribution of all the possible trajectories obtained by the numerical model, weighted by their corresponding breakdown variable W.

This method has indeed the purpose to predict the voltage holding capability of complex research devices for which it is not possible to build a prototype and to minimize time and cost in prototyping activity in industrial applications using medium/high voltage components vacuum insulated.

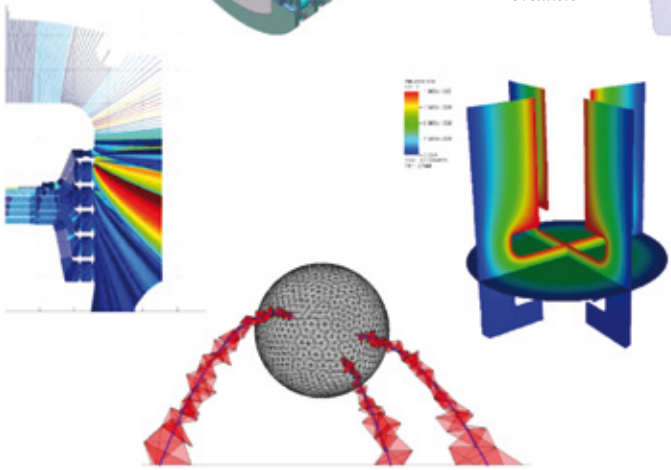
Complex experimental HV device

Electrostatic accelerator of the ITER Neutral Beam Test Facility



Industrial MV application

Vacuum circuit breakers



Ingegneria dell'energia

Energy Engineering

DII research group

Plasma Physics and Engineering

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The research activity on VCBs is carried out in collaboration with:
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Eng. Tommaso Patton, CRF, University of Padova
Prof. Ruben Specogna, DPIA, University of Udine
Dr. Eng. Andreas Lawall, Siemens AUG, Berlin
Dr. Eng. Nicola Pilan, Consorzio RFX, Padova
Eng. Antonio De Lorenzi, Consorzio RFX, Padova

Main research topics:

- Plasma physics and engineering
- Design of Neutral Beam Injector (NBI)
- Plasma active and passive diagnostics
- Analysis, synthesis and optimization of magnetic configurations
- Fusion reactor studies

Scienza Computazionale

Computational Science

DII research group
COMS - Computational Materials Science

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The study was conducted in the framework of the ERC Consolidator grant 'Computational Modelling of Structural Batteries'.

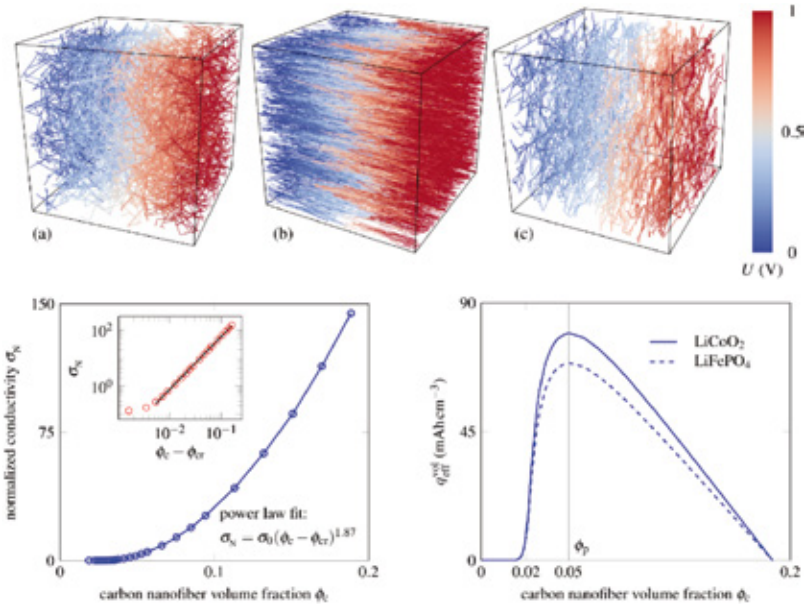
Researchers: Mingzhao Zhou (TU Delft) and dr. Davide Grazioli (TU Delft)

European Research Council
Established by the European Commission

Main research topics
- Computational Methods
- Multi-scale Modeling
- Mechanics of Materials
- Modeling of Failure for Brittle and Ductile Materials
- Micromechanics of Defects
- Phase Transformations
- Contact and Friction
- Structural Batteries

Computational Modelling and Simulation of Fiber-Based Electrodes

A structural battery is a novel design concept for an energy storage device. By endowing the battery components with a structural function, it is conceptually possible to eliminate the rigid casing of traditional batteries. Such an approach would immediately reduce weight and size of portable devices and make room for radically different form factors in consumer electronics. This concept is also being investigated by Volvo (composite battery-in-body-panel technology) and NASA (structural battery walls to power CubeSats).
A structural Li-ion battery can be devised using a fiber-reinforced composite material in which active and conductive material fibers are randomly dispersed in a solid polymer electrolyte matrix. The optimal mixture of active and conductive inclusions is a compromise between electrochemical and mechanical requirements: conductive fibers have to form a uniformly distributed conductive network leaving enough room for active fibers to guarantee a reasonable energy storage capacity; at the same time, mechanics requires fibers stiff enough to guarantee the load bearing capacity of the composite without electrochemically-inactive (additional) reinforcement.
One of the studies conducted in the context of the ERC project 'Computational Modelling of Structural Batteries' regards the determination of the effective conductivity and capacity of fiber-based electrodes. As in any composite, the overall response depends on its fiber content and orientation if all other characteristics are kept unchanged. As a way of example, the figure below shows the electric potential field when the carbon nanofibers are (a) distributed in an isotropic manner, (b) aligned, or (c) perpendicular with respect to the direction along which the voltage is applied. The figures at the bottom show that the conductivity in the isotropic case increases exponentially with the fiber volume fraction, whereas the electrode capacity is maximized for a specific carbon nanofiber content that does not depend on the active material. The optimal composition of structural battery electrodes should balance these findings against the requirements of the target application.



Modelling Contact between Metal Surfaces

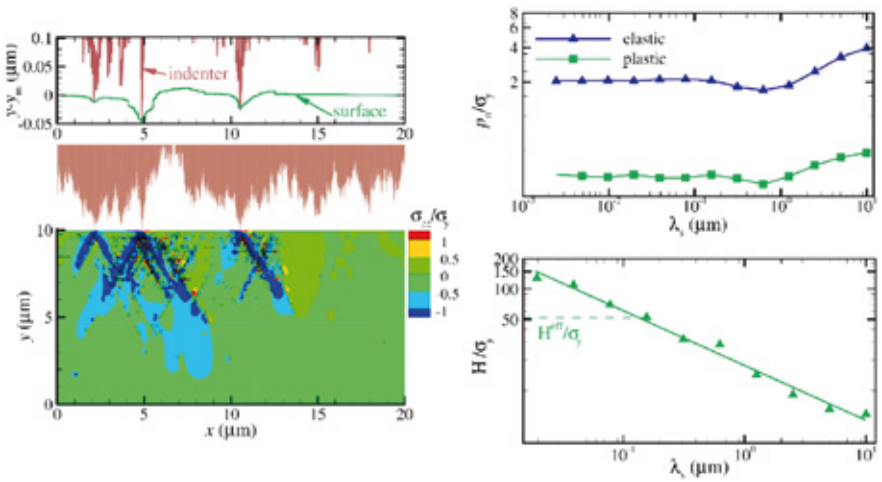
Metal surfaces, even when visually flat, have a self-affine rough character, with roughness spanning several decades in length scales. When metal bodies are pressed against each other, they touch only at the summits of surface asperities. The contact stresses are therefore very large even at moderate applied load and give rise to plastic deformation.

Keeping track of the deforming contact area and of the consequent change of contact stresses during loading is of great technological importance because it allows to understand and control phenomena such as friction, wear, adhesion, fretting, and contact fatigue. However, experimentally, it is very challenging to measure local changes in contact area, given that metal surfaces are non-transparent.

While there is an abundance of numerical models to study contact between elastic bodies, little attention was so far devoted to plasticity. The Computational Materials Science group has developed a novel computational technique called Green's Function Dislocation Dynamics that can be used to study the plastic deformation of metal bodies with self-affine rough surfaces. Plasticity in the body is modeled considering the collective motion of the individual dislocations in the bodies, described analytically. The image fields of the dislocations are calculated using Green's Function Molecular Dynamics, a boundary element method, which relies on damped dynamics in Fourier space to find the static equilibrium solution of elastic contact problems.

Simulations are performed while changing the main parameters of the surface roughness, i.e., root-mean-square height, Hurst exponent, fractal discretization. The aim of the work is to gain understanding in how plastic deformation affects the contact area, contact pressure and hardness, gap profile and subsurface stresses, while the roughness of the surface is changed.

Plastic deformation is found to be more pronounced for surfaces with larger root-mean-square height and/or Hurst exponent, and to be size dependent. Contact hardness is found to be much larger than what reported by classical plasticity studies. Primarily, this is caused by limited dislocation availability.



Scienza Computazionale

Computational Science

DII research group

COMS - Computational Materials Science

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This work is conducted in the framework of the ERC Consolidator grant 'A Seamless Multiscale Model for Contact, Friction and Solid Lubrication'.

Collaborators: Syam Parayil Venugopalan (ASML), Yaswanth Murugesan (PhD student, UNIPD), dr. Jianjun Bian (researcher, UNIPD), dr. Leonid Dorogin (researcher, UNIPD), dr. Peter Szabo (researcher, UNIPD).

There are currently several vacancies in the group.

European Research Council
Established by the European Commission

Main research topics:

- Multi-scale Modeling
- Mechanics of Materials
- Computational Methods
- Modeling of Failure for Brittle and Ductile Materials
- Micromechanics of Defects
- Phase Transformations
- Contact and Friction
- Structural Batteries

Fisica Ambiente Costruito

Building Physics

DII research group

Physics of Indoor Environment

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http://www.dii.unipd.it/en/physics-indoor-environment

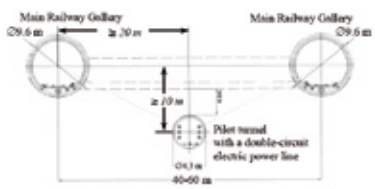
This research activity is carried out in collaboration with Prof. Roberto Benato of Power System Group of the Department of Industrial Engineering.

Main research topics:

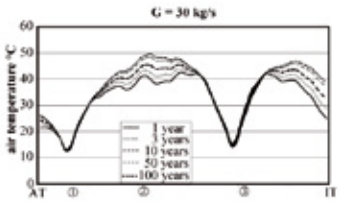
- Thermal behavior of buildings and building components
- Heating ventilating and air-conditioning systems
- Indoor climatic conditions and comfort levels
- Fire safety
- Indoor and outdoor acoustics: analyses, laboratory and field measurements.

Thermal Behaviour of Alpine Base Tunnels

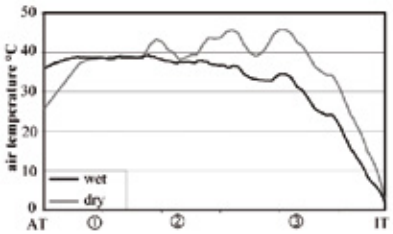
Remarkable overheating is often experienced in underground structures as a consequence of their internal heat gains, which may be not extremely high but are lasting for a long time. Quite typical is the case of many railway tunnels (e. g. the London Tube or the subway in Rome), but similar phenomena may also occur in other underground cavities. This research deals with the thermal behavior of Alpine base tunnels in presence of heat generation due to possible power lines installed inside the tunnel itself. Two meaningful cases have been investigated. First, a double-circuit power line inside the pilot tunnel of the high-speed railway tunnel under construction between Italy and Austria (Brenner Basis Tunnel, BBT) has been considered. Since the active power losses generated by a possible power transmission line may likely be about 7 MW, the thermal behaviour of BBT pilot tunnel and its ventilation requirements have been evaluated by resorting to a suitable computer model. This model is based on a "control volume" approach: a discretization of the space and time domains leads to a network of thermal capacities and resistances to be solved time after time by means of a linear algebraic system. In a similar way, also the possible installation of a power line inside LTF tunnel ("Lyon-Turin Ferroviaire") is certainly of some concern for the designers, since the heat generatied by the conductors is added to the thermal power due to the movement of the trains. On the other side, the main countermeasure to overheating (i.e. mechanical ventilation of the tunnel) is quite difficult for LTF project and, at least in principle, the tunnel should be ventilated by piston effect only. Therefore, the thermal behaviour of the tunnel has been assessed, once again, by resorting to a suitable computer model and some results are reported hereafter. As well known, this project has not been realized yet but it has been a forerunner of the HVDC-VSC cable line between Italy and France along the highways and inside the service tunnel of Frejus .



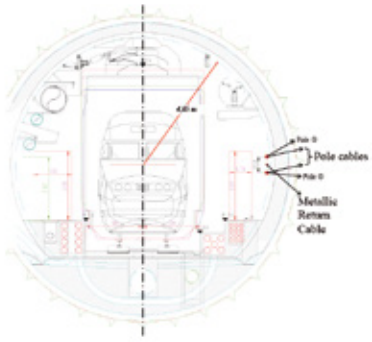
Brenner pass railway galleries and pilot tunnel



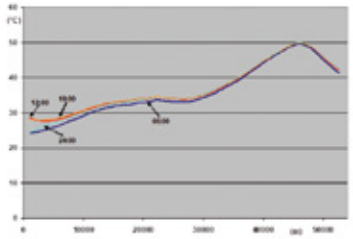
Air temperature along the Brenner pilot tunnel at different times of operation (air-flow rate 30 kg/s)



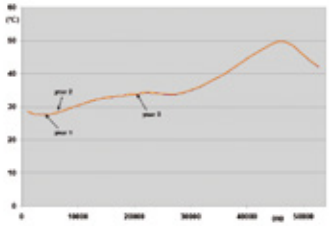
Air temperature profile along the Brenner pilot tunnel after 1 year with and without



Cross-section of LTF tunnel with DC cables



Conductor temperature along the LTF tunnel at different times of the day on June 30th of the first year with ventilated air gap at 5 m/s



Conductor temperature along the tunnel on June 30th, 12:00, for different years of operation, ventilated air gap at 5 m/s

Achievements

Roberto Benato premiato con il titolo di CIGRÉ DISTINGUISHED MEMBER

Durante la 47 CIGRÉ plenary session Roberto Benato è stato premiato con il titolo di CIGRÉ DISTINGUISHED MEMBER. Tale riconoscimento viene attribuito a membri individuali di lunga data (oltre dieci anni di appartenenza) che hanno contribuito in modo significativo alle attività dell'associazione. Solo 650 membri (27 italiani) della CIGRÉ sono distinguished member su 15000 totali.
Roberto Benato è il secondo accademico dopo il prof. Francesco Iliceto ad aver ottenuto questo riconoscimento nella CIGRÉ.

Per ulteriori informazioni rivolgersi a:
Roberto Benato
(049 8277532, roberto.benato@unipd.it)

Il DII tra i fondatori di INCAS (Ingegneria Cardiovascolare Strategica)

Il Dipartimento di Ingegneria Industriale è tra i dipartimenti fondatori di INCAS (Ingegneria Cardiovascolare Strategica). Si tratta di una Infrastruttura Strategica di Ricerca dell'Università di Padova frutto della sintesi di un insieme di collaborazioni che negli ultimi anni hanno coinvolto ricercatori delle aree ingegneristica e medica.
Alla base di INCAS vi è la necessità di dare risposta tecnica efficace ai quesiti clinici per la diagnosi e la cura di malattie cardiovascolari, insieme alla consapevolezza che le attuali capacità sperimentali e di calcolo possono finalmente risolvere problemi complessi e fortemente multidisciplinari.
Oltre al DII, partecipano:
DICEA (Dipartimento di Ingegneria Civile, Edile e Ambientale)
DCTV (Dipartimento di Scienze Cardio-Toraco-vascolari e Sanità Pubblica)
DSDB (Dipartimento di Salute della Donna e del Bambino)
DSEA (Dipartimento di Scienze Economiche e Aziendali "Marco Fanno").
Per il DII sono direttamente coinvolti in INCAS Paolo Bariani e Andrea Bagno.
Il Progetto è stato finanziato tramite Bando ISR UNIPD 2017 - Finanziamento INCAS per € 284.400 (Ateneo € 199.600 - Cofin Dipartimenti € 84.800).

Per ulteriori informazioni rivolgersi a:
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