Compte rendu XXI ICPIG 2013
International Conference on Phenomena in Ionized Gas

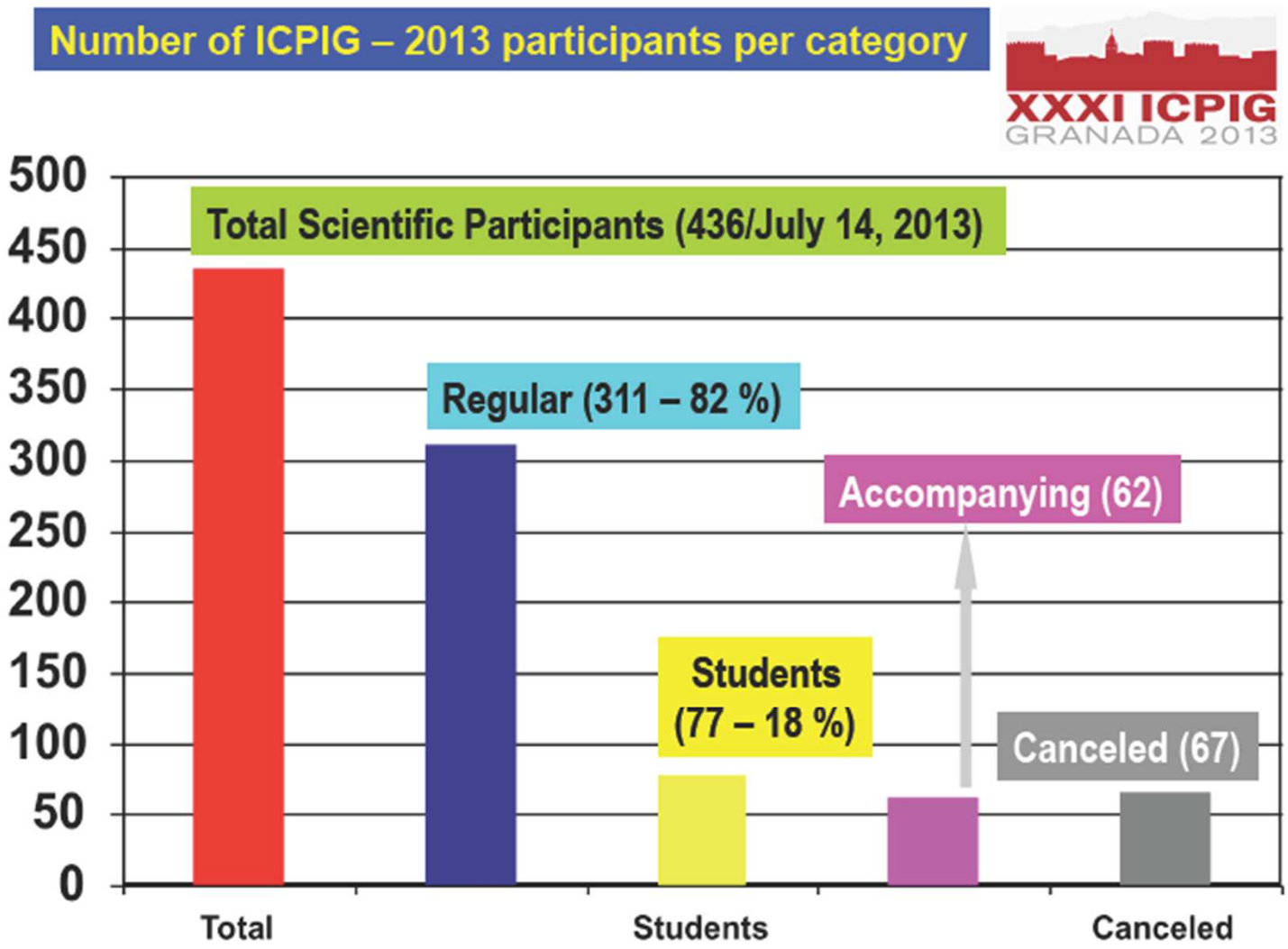
Granada

Frais d'inscription = 430€
Nbre de participants = 436

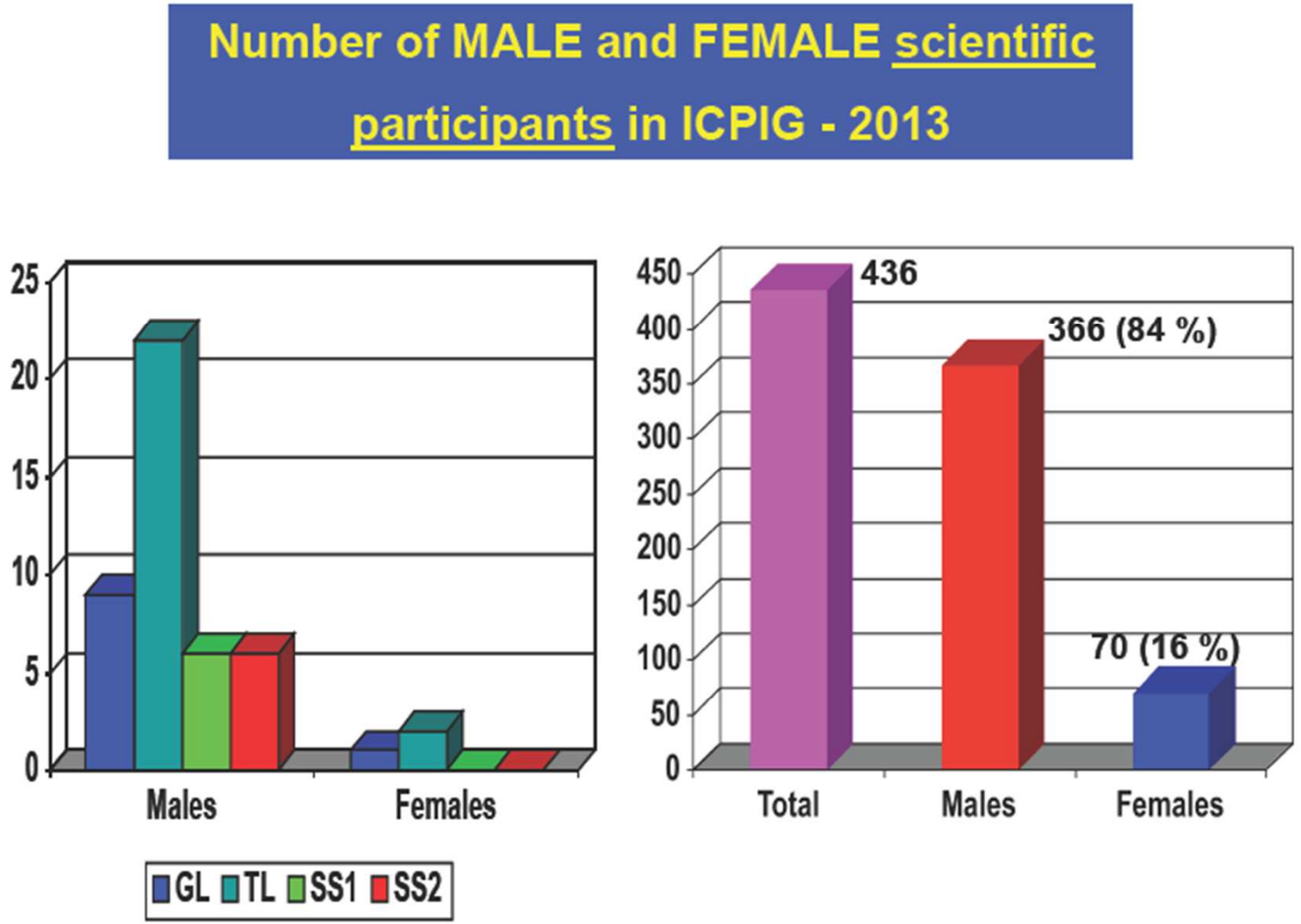
http://www.icpig2013.net

Lieu : Le centre de congrès de la Ville de Grenade

Participants

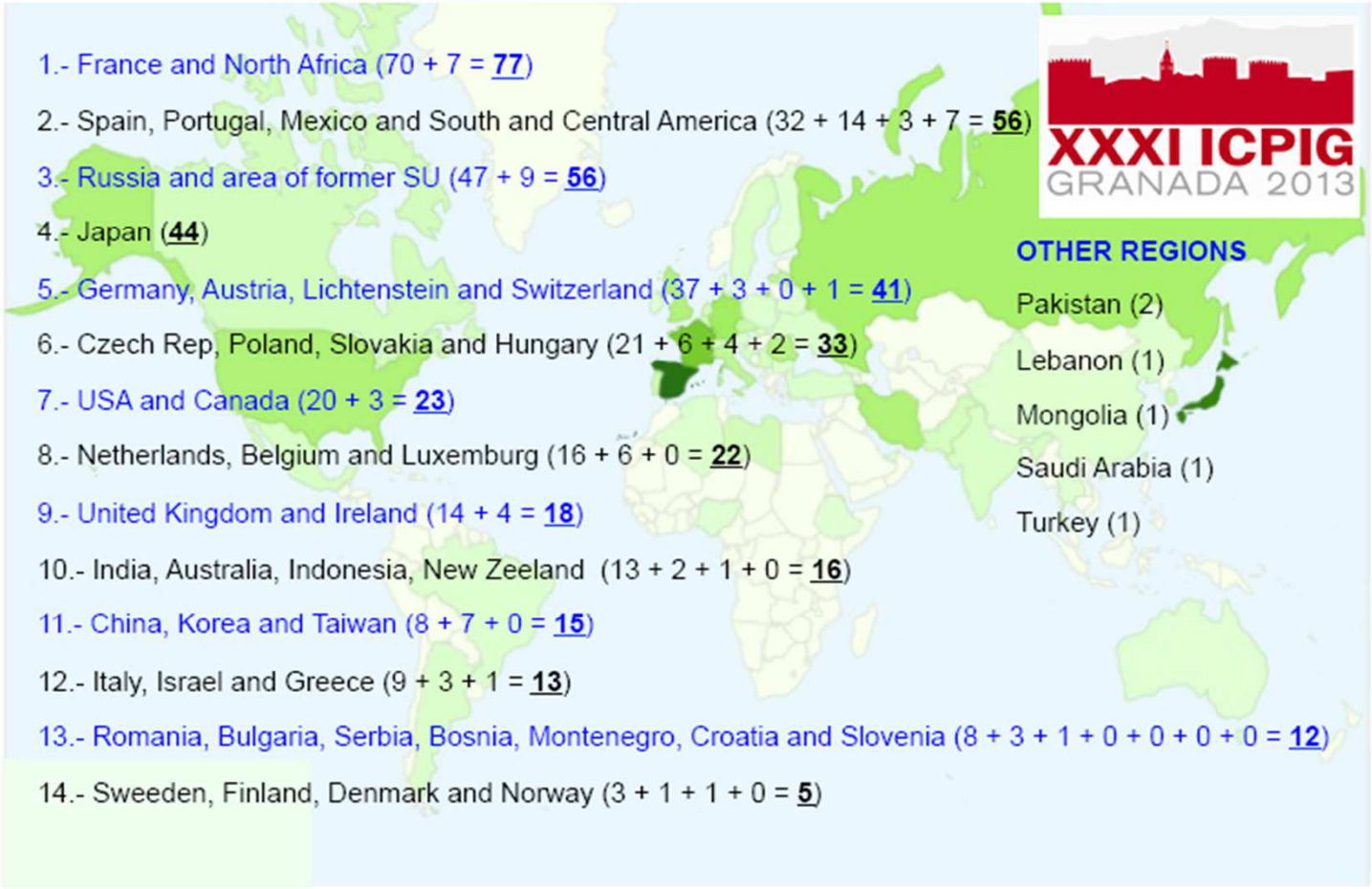


Une statistique étonnante : Les plasmas sont ils sexistes??



Répartition géographique

Number of participants divided into the 14 ICPIG - GEOGRAPHICAL regions



1.- France and North Africa (70 + 7 = **77**)

2.- Spain, Portugal, Mexico and South and Central America (32 + 14 + 3 + 7 = **56**)

3.- Russia and area of former SU (47 + 9 = **56**)

4.- Japan (**44**)

5.- Germany, Austria, Lichtenstein and Switzerland (37 + 3 + 0 + 1 = **41**)

6.- Czech Rep, Poland, Slovakia and Hungary (21 + 6 + 4 + 2 = **33**)

7.- USA and Canada (20 + 3 = **23**)

8.- Netherlands, Belgium and Luxemburg (16 + 6 + 0 = **22**)

9.- United Kingdom and Ireland (14 + 4 = **18**)

10.- India, Australia, Indonesia, New Zeeland (13 + 2 + 1 + 0 = **16**)

11.- China, Korea and Taiwan (8 + 7 + 0 = **15**)

12.- Italy, Israel and Greece (9 + 3 + 1 = **13**)

13.- Romania, Bulgaria, Serbia, Bosnia, Montenegro, Croatia and Slovenia (8 + 3 + 1 + 0 + 0 + 0 + 0 = **12**)

14.- Sweeden, Finland, Denmark and Norway (3 + 1 + 1 + 0 = **5**)

OTHER REGIONS

Pakistan (2)

Lebanon (1)

Mongolia (1)

Saudi Arabia (1)

Turkey (1)

Thématiques

4 grands thèmes, 17 thématiques

A/ Fundamentals

- T1: Elementary processes and fundamental
- T2 : Thermodynamic and transport phenomena
- T3 : Plasma walls interactions, electrode and surface effects
- T4 : Collective and nonlinear phenomena

B/ Modeling, simulation and diagnostics

- T5 : Modeling and simulation techniques
- T6 : Plasma diagnostic methods

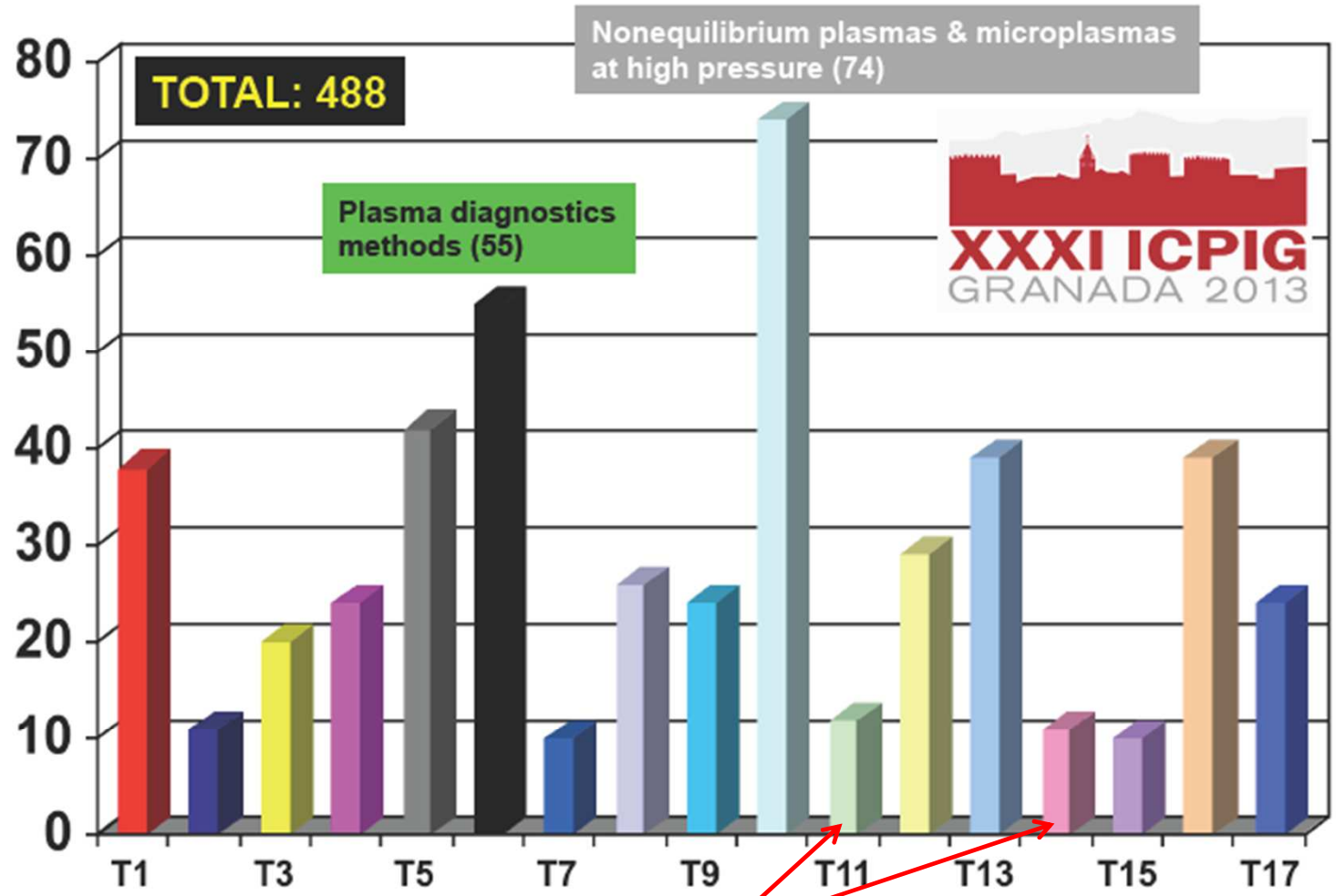
C/ Plasma sources and Discharges regime

- T7 : Astrophysical, geophysical and other natural plasmas
- T8 : Low pressure plasmas
- T9 : High frequency discharges
- T10 : Non-equilibrium plasmas and micro plasmas at high pressures
- **T11 : Thermal plasmas**
- T12 : Complex and duty plasmas, ion – ion plasmas mixed phase plasma

D/ Applications

- T13: Plasma processing of surfaces and particles
- **T14 : High pressure and thermal processing**
- T15 : Plasma lamps and radiation sources
- T16 : Medial, biological, environmental and aeronautical applications
- T17 : Plasma power and pulsed power technology, particle sources

Nombre de résumés soumis et répartition



22 papiers “plasmas thermiques”

4%

Organisation

- 10 conférences générales de 45 minutes, Aucune sur les plasmas thermiques

- 24 Conférences « thématiques » de 30 minutes
  - Thermique : 3D fluid dynamic modelling of RF plasmas, Masaya Shigeta (Japon)
  - Matériaux: Development and integration of plasma-assisted unit operations for the synthesis of MWCNTs-based nanostructures and nanofluids Sylvain Coulombe (PPL, Canada)

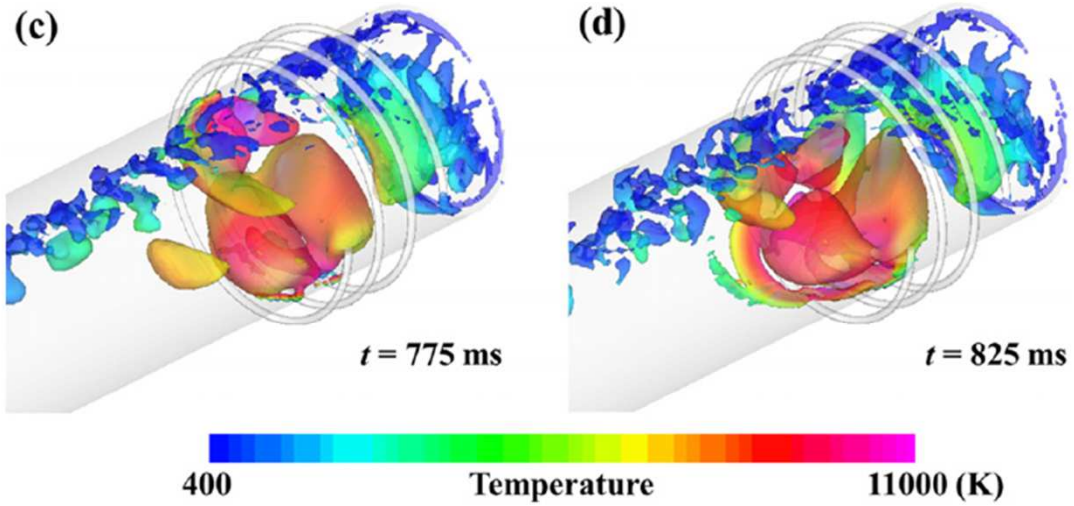
- 2 Sessions spéciales
  - Plasma Space propulsion
  - Plasma flow and combustion

- 4 Sessions poster
  - 22 posters, seulement xx présents

3D fluid dynamic modelling of RF plasmas, Shigeta M (1)

Sujet principal : Modélisation de torches RF

This paper presents recent modelling results of RF plasmas, which have yielded new insights into the three-dimensional structure and dynamics of RF plasma flows without/with a stationary central injection of a plasma jet. The numerical results show that the flows have complicated 3D structures with noticeable recirculating zones. Those recirculating flows prevent the cold sheath gas from flowing downstream through the plasma. The higher-temperature regions in and around the plasma exhibit larger vortex structures principally by the Lorentz force, whereas the lower-temperature flows form smaller eddies by fluid dynamical instability around the plasma. A plasma jet breaks such a structure in the RF coil region, and consequently the flow becomes more complicated.



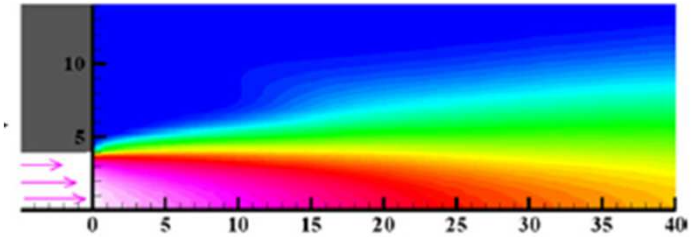
RF 4Mhz, 6kW
Argon Gas, 23 L/min

Points spécifiques :

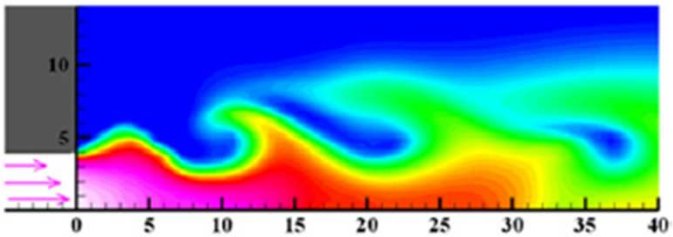
Des schémas numériques spécifiques

- Adams Brashford method (ABM du second ordre) temporel
- 2nd ordre pour la convection (mix upwind + differences finies)

Un modèle de turbulence Sub Grid Scale (proche LES)



(1st-order EM, $\alpha = 0.0$ (upwind))
$t = 4.4$ ms



(2nd-order ABM, $\alpha = 0.9$)
$t = 4.4$ ms

Il retrouve des effets tourbillonaires… Reste la validation

Sujet principal : Productions de Nanotubes et nano particules + Applications

We report on the development and integration of multiple unit operations with an overall goal to provide flexible means to produce multiwall carbon nanotube (MWCNT)-supported heterogeneous nanostructures and stable colloidal suspensions (MWCNT-based nanofluids). The main unit operations are thermal chemical vapour deposition (t-CVD) for the synthesis of MWCNTs directly from stainless steel, low-pressure capacitively-coupled RF (13.56 MHz) plasma polymerization-functionalization, and pulsed laser ablation (PLA) synthesis of nanoparticles (NPs). Four successful application examples are presented: i) High temperature-stable MWCNT nanofluid for solar thermal energy harvesting; ii) MWCNT-supported Ni NP electrocatalyst for H_2 production by water electrolysis; iii) Au NPs-decorated MWCNT nanofluids as optically-active biological media, and iv) *in-situ* synthesis of MWCNT-ECP (electro-conductive polymer) electrodes.

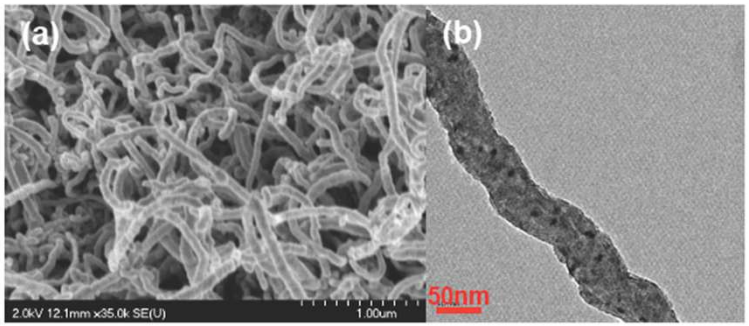


Fig. 3.2. SEM (a) and TEM (b) images of Ni NP-decorated MWCNTs.

Points spécifiques

Présentation d'une unitée de production de NP R&D basée sur différentes techniques

1/ Thermal CVD (plaque métal + acétylene + Four) = production MWCNT

2/ Rf plasma basse pression=polymerisation / Functionalization du NT

3/ Thermal Evaporation / Condensation à partir de billes de matériaux chauffées=Production de nano particules

4/ Pulsed Laser Ablation = Production de nano particules

5/ Pulsed Cathodic arc Erosion = Production de NP metalliques à basse pression

6/ Ultrasonication & dispersion = Arrachement des NP de leurs différents sites pour les mettre dans un fluide

Exemple d'applications

- Optimisation du fluide pour transfert de chaleur dans du solaire
- Thérapeutique par fonctionalisation

Bon papier de présentation des techniques actuelles pour production de NP et NT et de leurs applications

Plasma diagnostic methods :

- Structure of cutting arc examined by Fourier transform and generalized correlation dimension, *Gruber J. & al (IT Prague, Rep Tchèque)*

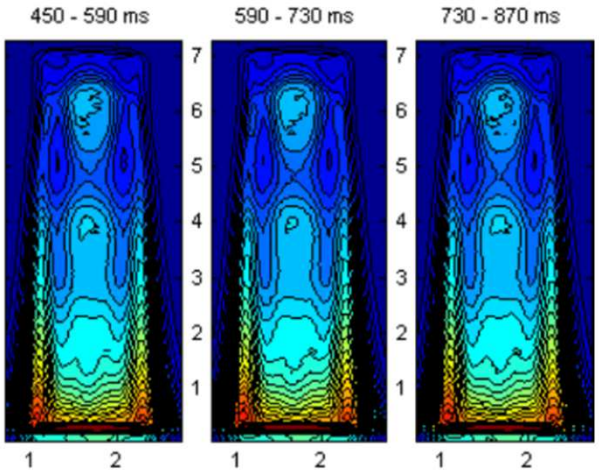
Thermal plasmas

- Spectroscopic investigations of electric arc plasma with additions of copper and molybdenum, *Veklich A. & al (Kiev University, Ukraine)*

Structure of cutting arc examined by Fourier transform and generalized correlation dimension, *Gruber J. & al*

Sujet principal : Exploitation d'images d'arc de découpe pour détection de comportement

Structure and stability of arc plasma was examined by several methods in cutting DC plasma torch operating with air. Plasma was produced in commercial air plasma cutting system with shielding gas and experimental nozzle in non-cutting setup with rotating anode. Arc radiation was recorded by high-speed CCD camera and analyzed by calculating standard deviations, Fourier transform and generalized correlation dimensions. These methods yielded various views of arc inner structure and its short-time development. Besides compression and expansion zones caused by gas supersonic flow, two distinctive layers in the arc structure created by hydrodynamics effects and helical structure at the arc axis suggesting rotational movements were detected.



Structure of cutting arc examined by Fourier transform and generalized correlation dimension, *Gruber J. & al*

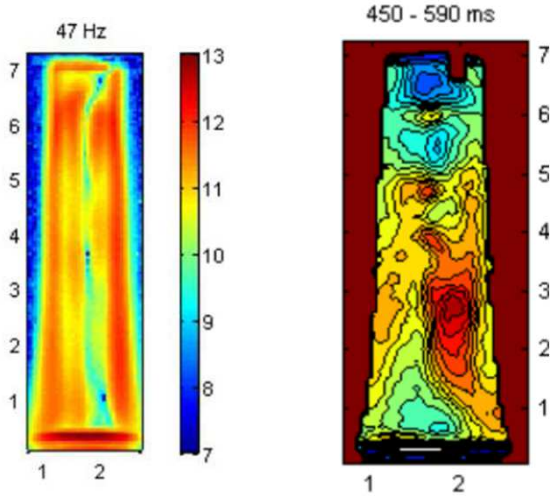
Points spécifiques :

Mesures par caméra rapide + traitement FFT

FFT, mais aussi méthodes de corrélation

Apparition de différentes structures de l'arc

- Structure complexe à double couche (gaz froid + Chaud)
- Structures hélicoidales, apparition de structures complexes



Encore prospectif, difficile de relier les informations des graphs aux réelles propriétés de l'arc

Spectroscopic investigations of electric arc plasma with additions of copper and molybdenum, *Veklich A. & al*

Sujet principal : Caractérisation d'une décharge d'arc entre des életrodes composites Cuivre/ Molybdene

The aim of this work is determination of plasma parameters of electric arc discharge between Cu-Mo composite electrodes in argon flow. The radial profiles of plasma temperature and electron density, obtained by optical emission spectroscopy, were used in calculation of plasma composition in assumption of local thermodynamic equilibrium. It was found that ionization of copper and molybdenum components have comparable contribution in plasma channel conductivity. Additionally Boltzmann plot method was used, as convenient instrument for analysis and selection of MoI spectral lines and their spectroscopic data. In result of such procedure oscillator strength of several MoI spectral lines are recommended.

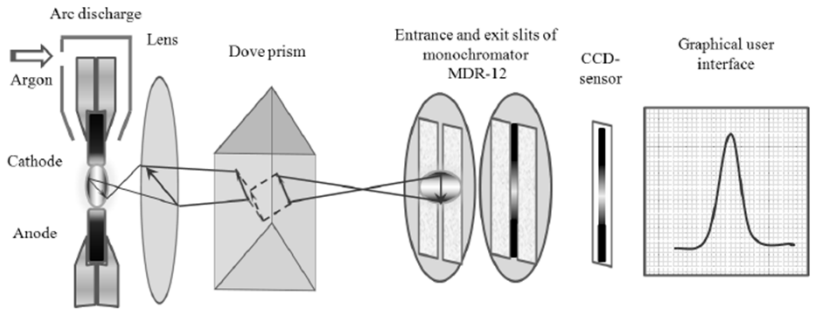


Fig. 1 Registration of spatial distribution of spectral line intensities

Spectroscopic investigations of electric arc plasma with additions of copper and molybdenum, *Veklich A. & al*

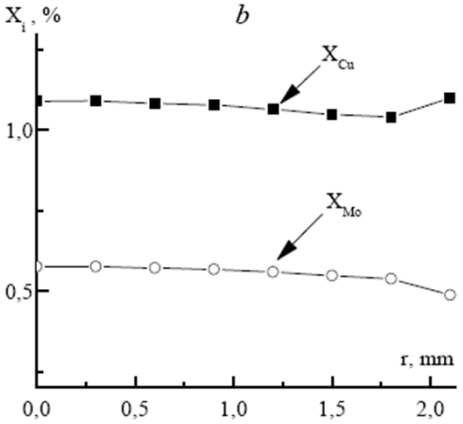
Points spécifiques :

Chaine de mesure spectro d'émission "classique"

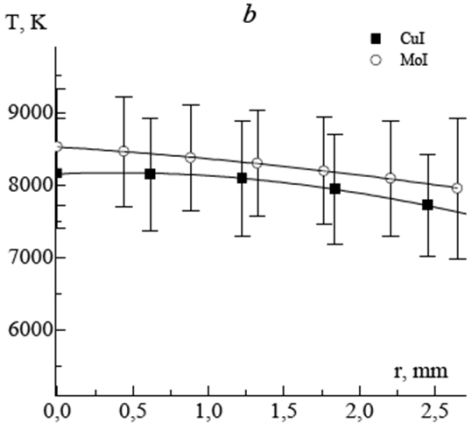
Utilisation d'un dove prisme

Mesures de la température dans l'arc (ETL)

- Diagramme de Boltzman sur raies de cuivre, Molybdène
- Obtention de la température des des fractions de Moblybdene et cuivre



30A
Argon gas



Spectro "classique" sur des espèces métalliques, information sur les raies à utiliser et l'érosion des électrodes "composites"

Session n°2 :

Plasma wall interaction :

- Calculation of thermo-emission cathodes at atmospheric pressures, *Nguyen-kuok S.&al (LPP Moscou, Russie)*

Thermal plasmas

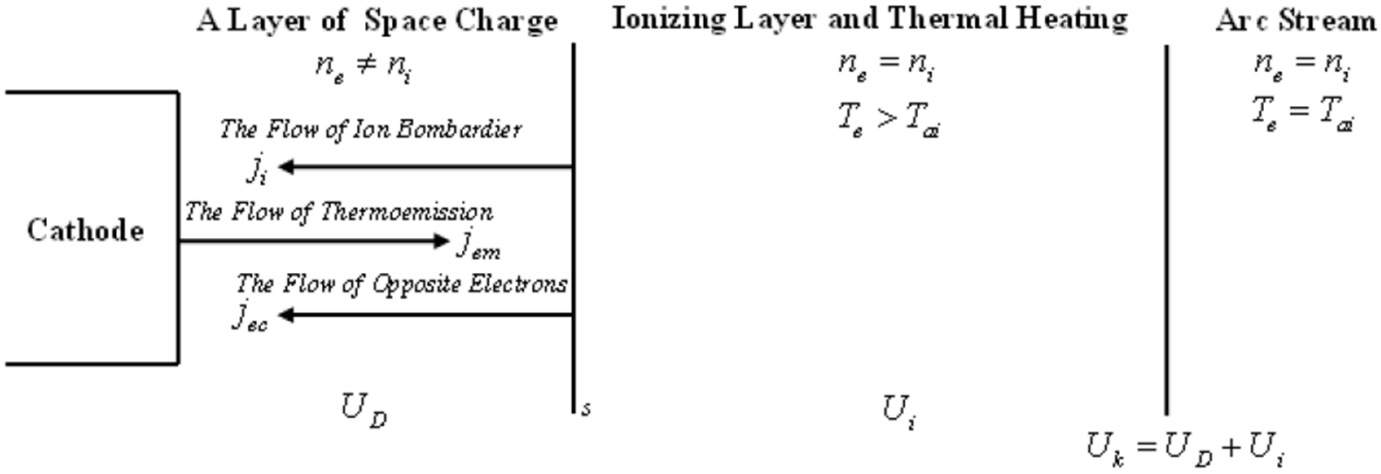
- Determination of copper impurities distribution in arc discharge plasma by technique of laser absorption spectroscopy, *Veklich A. & ak (Kiev University, Ukraine)*

- Air plasma radiation – choice of spectral intervals suitable for fast temperature measurements, *Hlina J. & al (IT Prague, Rep Tchèque)*

Calculation of thermo-emission cathodes at atmospheric pressures, *Nguyen-kuok S.&al*

Sujet principal : Modèle de gaine cathodique pour du tungstène et du tungstène thorié

Work gives results of calculating the cathode processes of the Arc plasma torches at atmospheric pressure with the thermal cathodes. Calculations were performed on the basis of the method of integral balances for the cathode made of the pure tungsten W and the thoriated tungsten W(2% ThO_2)) over a wide range of temperatures of cathodes (T_k = 3000 – 4400 K for W and T_k = 2000 – 3200 K for W(2% ThO_2)) and argon plasma (T_e = 20000 – 40000 K).

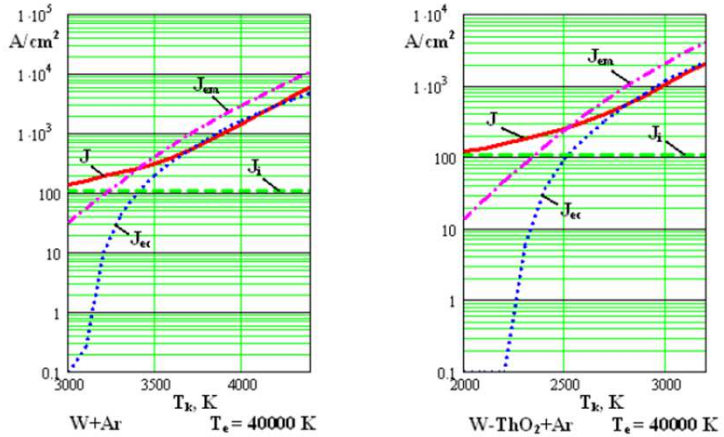


Calculation of thermo-emission cathodes at atmospheric pressures, *Nguyen-kuok S.&al*

Points spécifiques :

Estimation des flux de particules à paramètres imposés

- Impose Te, Th, J
- Obtient la tension dans la gaine, les flux de particules
- Fait pour deux types d'électrodes, tungstène pur et tungstène thorié



Très similaire au modèle de Benilov 95

Determination of copper impurities distribution in arc discharge plasma by technique of laser absorption spectroscopy, *Veklich A.*

Sujet principal : Mesure de concentration de cuivre dans un plasma d'argon

Technique of laser absorption spectroscopy was applied for diagnostics of electric arc plasma between composite Cu-Mo electrodes. Spatial brightness distributions of laser emission with and without the arc were registered by CCD-matrix in the realized experimental scheme. The special graphical user interface for experimental data treatment was developed. Obtained spatial distributions of copper atomic energy level $^5D_{5/2}$ population were used for calculation of plasma composition in assumption of local thermodynamic equilibrium. It was found, that electrode's fabrication technology has an influence on plasma properties. Particularly decreasing of metal vapour content in plasma has place in the case of electron beam evaporation and following condensation in vacuum fabrication technology.

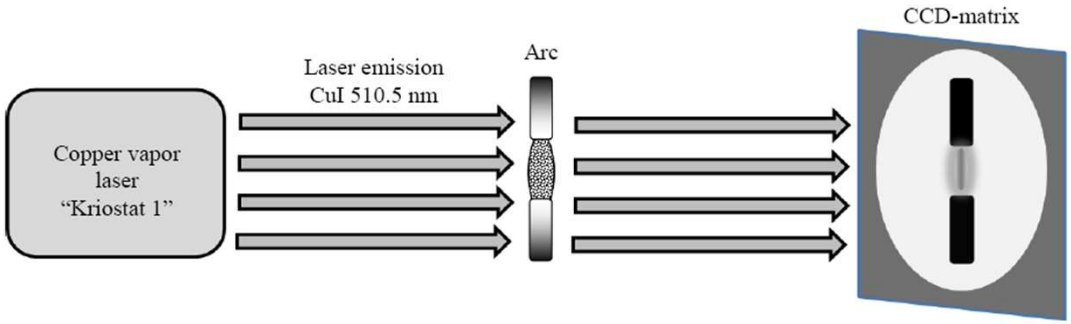
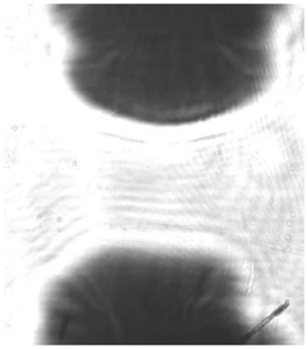


Fig. 1 Optical scheme of linear laser absorption spectroscopy

Points spécifiques :

Mesures de spectro par absorption

- Laser original à vapeur de cuivre
- Estimation de l'épaisseur optique, puis du coeff d'absorption du niveau $2D_{5/2}$ + profil raie élargie doppler = densité + Article précédent (T, ETL)= Concentration



a

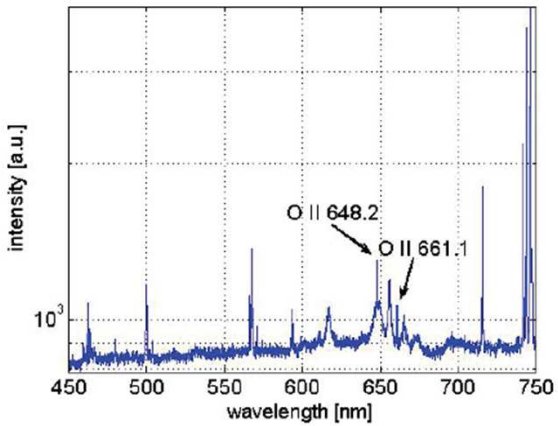
b

Permet de comparer spectro d'émission et absorption laser.
Permet de quantifier la décomposition d'électrodes composites

Air plasma radiation – choice of spectral intervals suitable for fast temperature measurements, *Hlina J. & al .*

Sujet principal : Mesures de température sans spectro résolue mais avec l'émission dans de large bandes dans l'air

Temperature measurements in air thermal plasma based on the detection of its radiation in wide spectral intervals can bring new possibilities in the development of diagnostic methods with high temporal and spatial resolutions. We have studied experimentally and theoretically the optical radiation of air plasma and searched for spectral intervals where the integral radiation in the interval is characterized by monotonous dependence on temperature. The experimental and theoretical investigations presented in this work have shown that the spectral interval 565-605 nm may fulfil these requirements although theoretical results predict a relatively flat slope for the dependence of radiation vs. temperature in the interval 16000-20000 K.

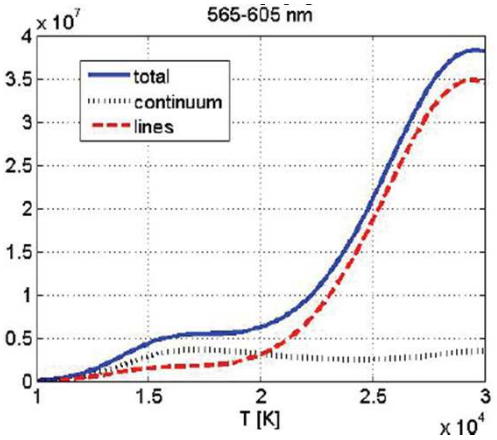


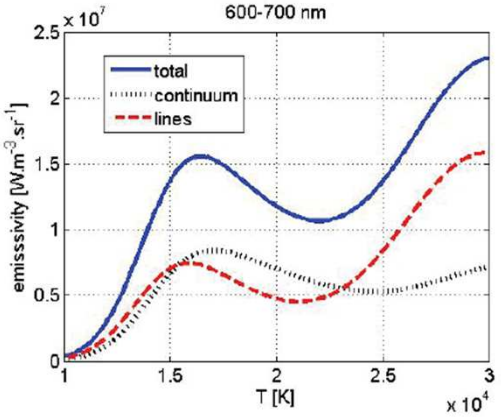
Air plasma radiation – choice of spectral intervals suitable for fast temperature measurements, *Hlina J. & al .*

Points spécifiques :

Comparaison expérience – théorie sur l'émission dans l'air

- Torche de découpe dans l'air, mesure de température maxi suivant l'intensité par méthode des raies relatives
- Détermination théorique de bande spécifiques pour mesurer la température à partir de l'émission
- Meilleure bande = 565 – 605 pour une gamme de 16 à





Prometteur mais encore des différences Expérimentales / theoriques à intrepréter

Session n°3 :

Plasma diagnostic methods

- Application of Mach Zender interferometer to parameters measurements in air arcs, *Zhou X. (DEE Beijing, China)*

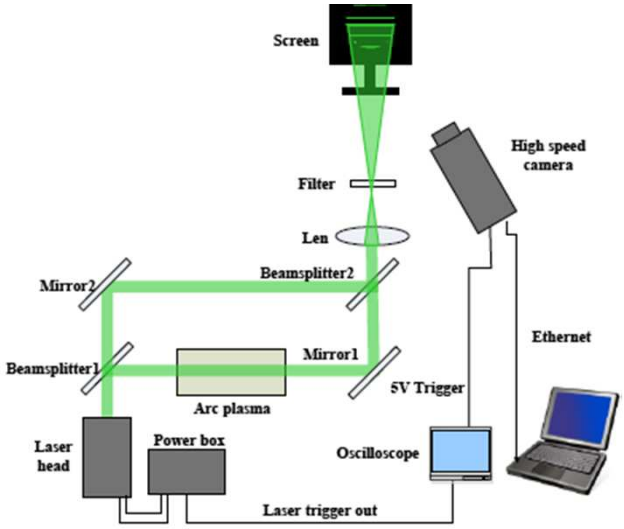
Thermal plasmas

- Influence of PTFE vapours in high-voltage circuit breakers, *Gonzalez JJ & al (Laplace,France)*
- Control, diagnosis and model of DC arc discharge applied to the synthesis of Carbon nanostructures, *Valvidia R. & al (ININ, Mexique)*
- Multi time electron density imaging over SF6 and air arc discharge around current zero, *Inada Y. &al (Beijing, China)*
- Spectroscopic investigation of multiple Boltzmann distributions of various atomic and ionic states in an expanding H2O-Ar DC arc jet, *Sember V. & al (IPP Prague, Rèp Tchèque)*

Application of Mach Zender interferometer to parameters measurements in air arcs, *Zhou X.*

Sujet principal : Mesure de température par interferométrie Laser

A Mach-Zehnder interferometer was set up to determine thermodynamic parameters in discharges such as temperature and particles concentration from the racial distribution of the refractive index which can be obtained from the fringe image. Research on air arcs was conducted to verify the measurements quantitatively. A thermodynamic model was established to obtain the relationship between temperature and densities of main particles such as electron and ions which determine the refractive index of arc plasma. Both AC arcs (0.1 A) and DC arcs (30 A) diagnostic experiments were conducted. The peak temperature of the former ones vary from 3000 K to 6000 K, while of the latter ones is about 12000K. It can be found that the arc temperature is associated with the instantaneous value of current instead of the gap distance from the results of the AC arc experiments. This study laid a solid foundation for the follow-up research on leader parameters.

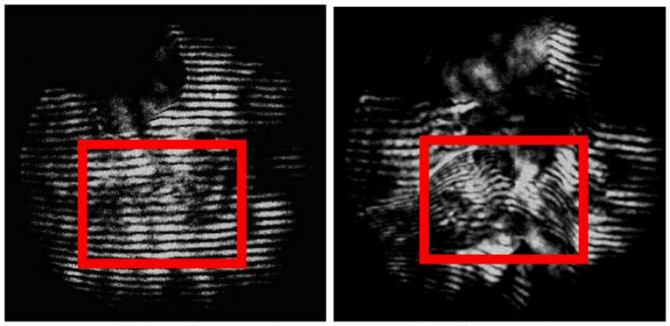


Application of Mach Zender interferometer to parameters measurements in air arcs, *Zhou X.*

Points spécifiques :

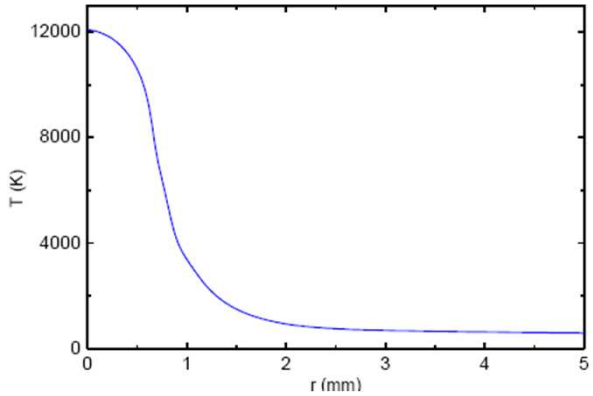
Mesure de température dans un plasma d'air par interferométrie

- Laser YAG pulsé
- Mesure sur arc DC (30A) et AC (0.1A)
- Obtention de la densité électronique puis sous ETL de la température



(a) background (b) diagnostic

Figure 4. Fringe images of DC arcs experiments, recorded by high speed camera with 1s exposure time.



Mesures intéressantes, application future à des leaders…

Sujet principal : Modélisation HVCB, influence ablation

One model is developed based on the @Fluent software to study the plasma behaviour in a high-voltage circuit breaker taking into account the vapours coming from the erosion of the PTFE walls. The main lines of the two dimensional transient model are presented. Following time, a sinusoidal current intensity and a piston stroke are assumed. Due to the erosion walls the initial SF_6 medium changes to a mixture of SF_6-C_2F_4. The self-induced magnetic forces are taken into account via an original method based on vector potentials resolution and Biot&Savart formulation. In this application plasma radiation plays an important rule on the pressure increase. The pressure evolution in the heating volume will be presented and compared with experimental results.

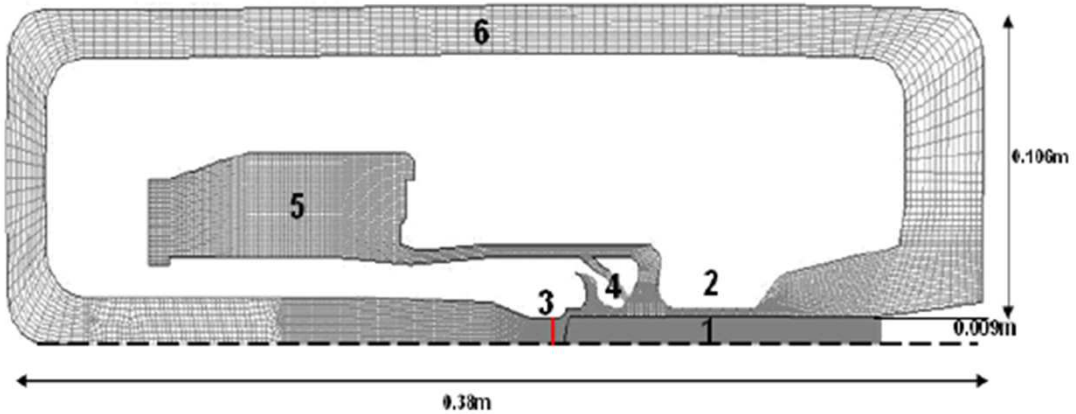
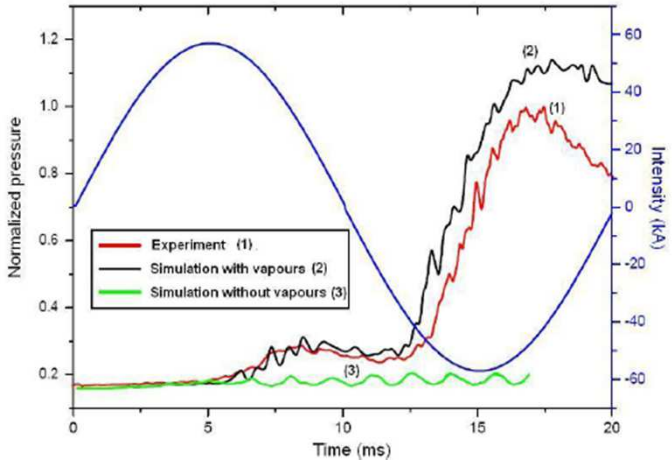


Fig. 1: Geometry studied.

Points spécifiques :

Modélisation de l'ablation du PTFE

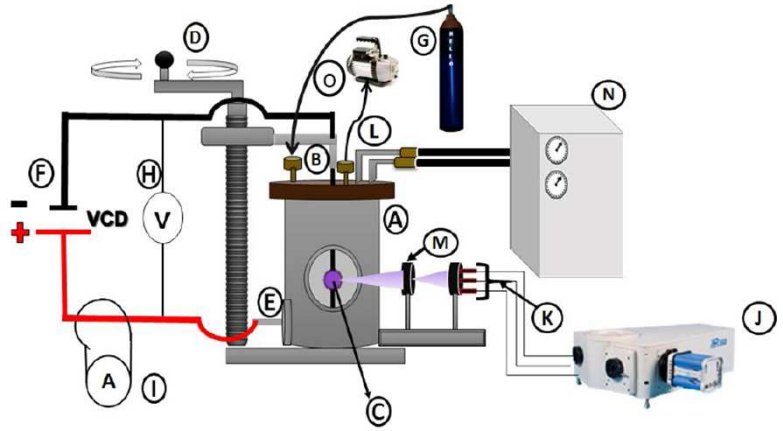
- Modèle fluide SF6/C2F4
- Modèle 2D dans géométrie réaliste
- Montée en pression suivant l'ablation ou pas de différentes parties de la tuyère



Ablation PTFE indispensable pour montée en pression dans Heating Volume

Sujet principal : Etude d'un réacteur pour la production de Nanotubes

In this paper the synthesis of carbon nanostructures (CNS) by DC arc discharge in a helium atmosphere is reported. The reactor having cooling system jacket allows operation at elevated gas temperature (T>3000 K). Inside the reactor, two graphite electrodes are vertically aligned; one of them is adapted with a mechanical system to adjust the gap distance and to control the anode erosion velocity. The control and diagnosis of electrical power source is performed by a LabView ® program. A model implemented in code Saturne to compute the temperature profile in the arc discharge is also presented. Optical emission spectroscopy diagnosis is applied to calculate the electron temperature in the arc discharge validating the simulation model. The CNS synthesis is demonstrated by the morphological analysis performed in TEM and SEM.



Points spécifiques :

Réacteur

- Arc DC fonctionnant dans l'hélium, ablation des électrodes dopéees

Mesures spectroscopiques + Caractérisation nanotubes

- Utilisation de fibres optiques
- Mesure de raies de Nickel + Diagramme de Boltzmann
- Mesures TEM

Modèle 3D du réacteur

- Utilisation de code_saturne
- Premiers résultats seulement

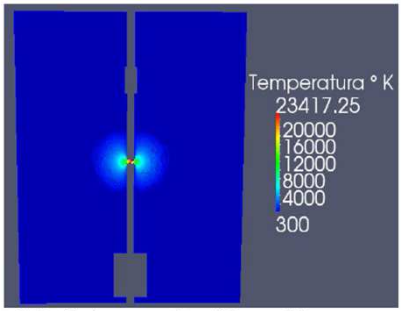
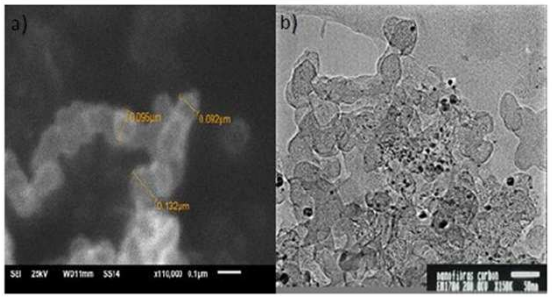


Fig. 6. Preliminary results of the model

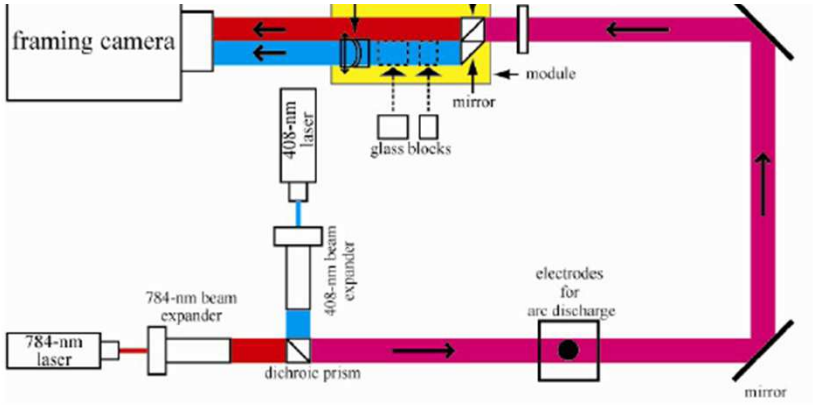


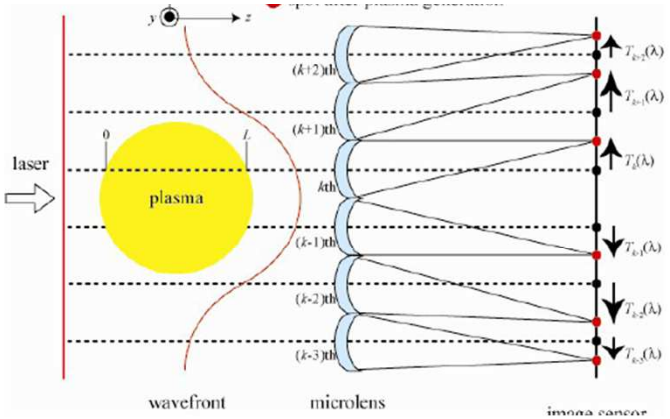
Etude "classique", pas de réelle comparaison modèle expérience, phase prospective

Multi time electron density imaging over SF6 and air arc discharge around current zero, *Inada Y. & al*

Sujet principal : Etude expérimentale de l'évolution de la densité électronique autour du courant zéro dans SF6 et air

Framing Shack-Hartmann type laser wavefront sensors were developed for measuring and comparing time evolutions of two-dimensional electron density images over a pulsed SF_6 and air arc discharge around current zero. These experimental results showed that SF_6 arc discharges had a rapid electron density reduction rate of $10m^{-3}/\mu s$ around arc extinction. In addition, distinct arc columns were observed in SF_6 arc discharges and they were surrounded by few residual electrons. On the other hand, atmospheric arc discharges around current zero had almost constant residual electron densities of $10^{22}m^{-3}$ surrounding the arc channels whose electron densities were estimated to be no more than $10^{22}m^{-3}$. Therefore, the air arc columns were not distinguished from the residual regions by the electron density images.



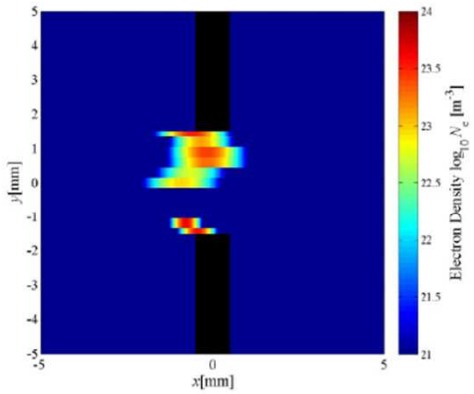


Multi time electron density imaging over SF6 and air arc discharge around current zero, *Inada Y. & al*

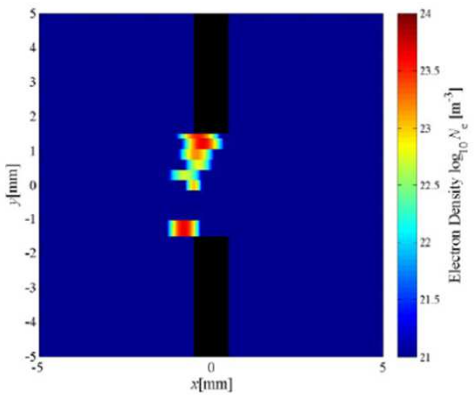
Points spécifiques :

Mesures

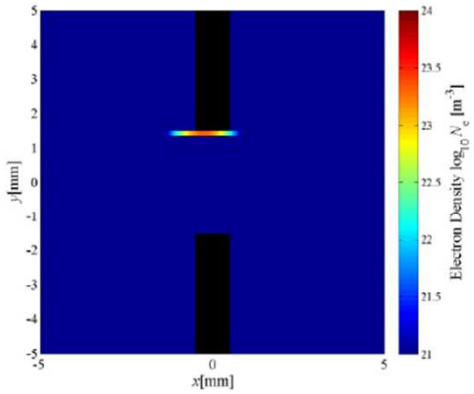
- Technique de mesure originale avec système shack hartman
- Précision moyenne de l'ordre de 2.10^{22} e /m^3
- Mesures résolues dans le temps, obtention de la vitesse de disparition des électrons
- Courant par décharge de capacité



(a) N_e distribution at t=-6µs



(b) N_e distribution at t=0µs



(c) N_e distribution at t=6µs

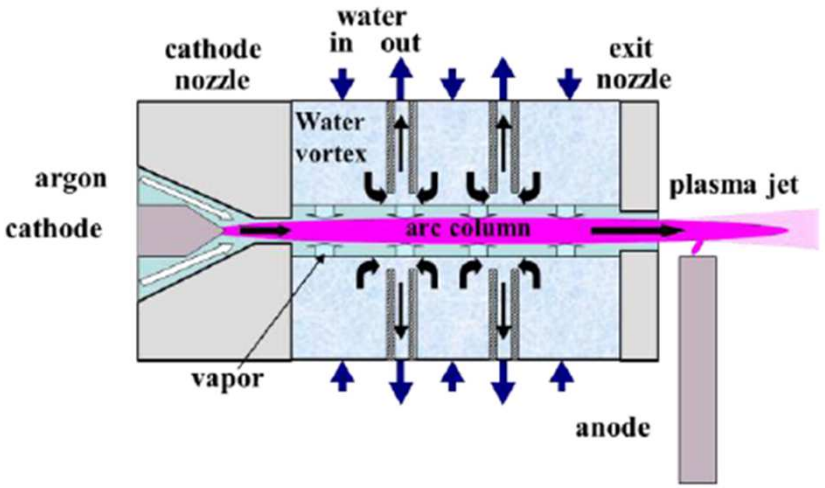
SF6, $dn_e/dt = 10m^{-3}/\mu s$

Méthode expérimentale originale, étude interressante autour du courant zero

Spectroscopic investigation of multiple Boltzmann distributions of various atomic and ionic states in an expanding H2O-Ar DC arc jet, *Sember V. & al*

Sujet principal : Mesure de déséquilibres thermiques dans une configuration de torche à eau sortant à pression reduite

Thermal plasmas are now widely used in many industrial applications as sources of heat or chemical species. There are a number of processes that cause deviations from the equilibrium state, which are manifested mainly in the chemical composition and population of excited species. Population distributions of argon atomic and ionic excited states in the supersonic part of a plasma jet expanding from the H_2O-Ar dc arc torch into a chamber maintained at a pressure of 10 kPa have been studied by optical emission spectroscopy.

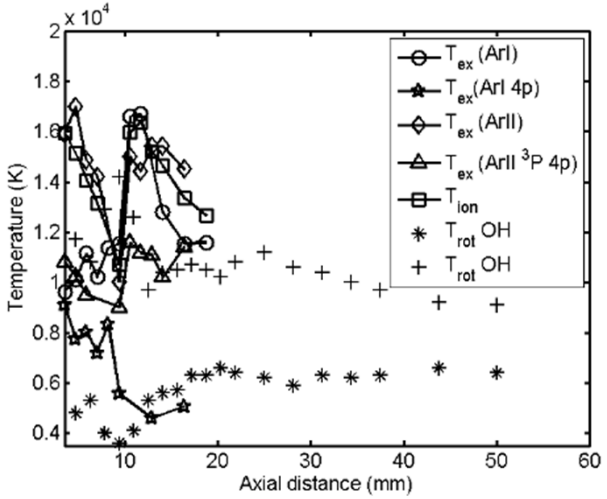


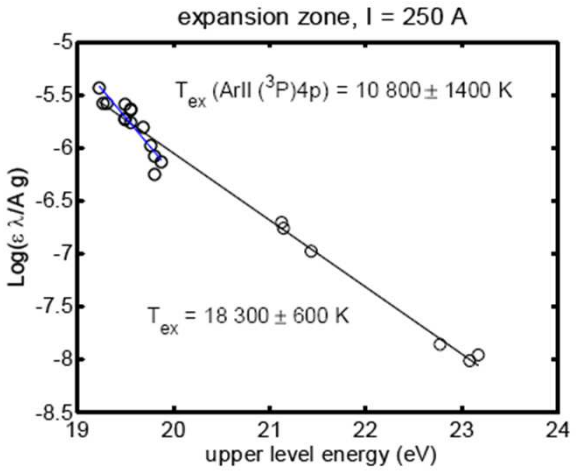
Spectroscopic investigation of multiple Boltzmann distributions of various atomic and ionic states in an expanding H2O-Ar DC arc jet, *Sember V. & al*

Points spécifiques :

Mesures pour une intenscité de 250A Argon + eau

- Mesure spectroscopique dans la zone d'expansion de l'onde de choc
- Mesures des populations d'argon neutre et une fois ionisé
- Mesure de la densité électronique par élargissement Stark de la raie Hα
- Mesure de trois tempérratures Trotationnelle avec OH, Température "d'excitation" avec Diagramme de Boltzmann, Température d'ionisaiton par rapport de raies de neutre et d'ion et la densité électronique





Les températures d'excitation et d'ionisation sont différentes, même pour une espèce, distribution par forcément à une température

Thermodynamic and transport phenomena

- Thermodynamic properties and transport coefficients calculation for two-temperature air methane plasma, *Dhouidoui R. & al (Laplace, France)*

Modeling and simulation techniques

- Challenges to simulating vacuum arc discharge, *Hopkins M. & al () (SNA Albuquerque, USA)*
- Simulating AC current transfer through near electrodes layers in very high pressure arcs by means of COMSOL Multiphysics*, Almeida N. & al (CCCEE Madeire, Portugal)*

Thermal plasmas

- Measurement of OH emission spectra in thermal plasma water – argon thermal plasma generated by the DC plasma torch, Sember V & al (Tchèquie).
- Influence of the plasma gas in TIG configuration, *Mougenot J,. & al (Laplace)*

Sujet principal : Calcul de composition et de propriétés 2T pour des mélanges air/méthane

Abstract: This work concerns the calculation of two-temperature (2T) air – methane plasma properties: compositions, thermodynamic properties (mass density, enthalpy and specific heat at constant pressure) and transport coefficients (thermal conductivity, viscosity and electrical conductivity). The composition is obtained from the 2T mass action law and from the conservation equations (pressure, electrical neutrality and atomic proportions). Thermodynamic properties are then calculated analytically from the composition. Finally, transport coefficients are obtained from the Chapman-Enskog theory (extended to the 2T case) and from recent theoretical developments. The 4 contributions to thermal conductivity (translation of electrons, translation of heavy particles, internal and reaction) are calculated separately so that they can be used in a different way in the two energy conservation equations (electrons and heavy particles) involved in 2T MHD models.

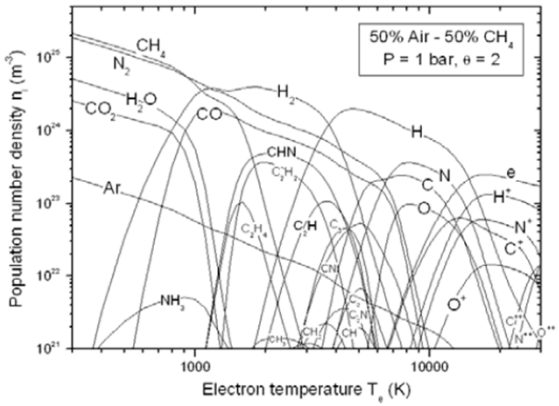


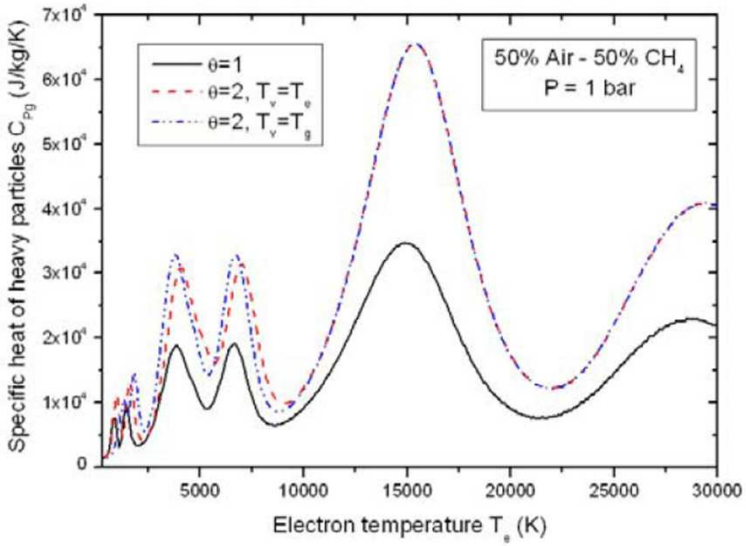
Fig 1. 2T plasma composition ($T_v = T_e$).

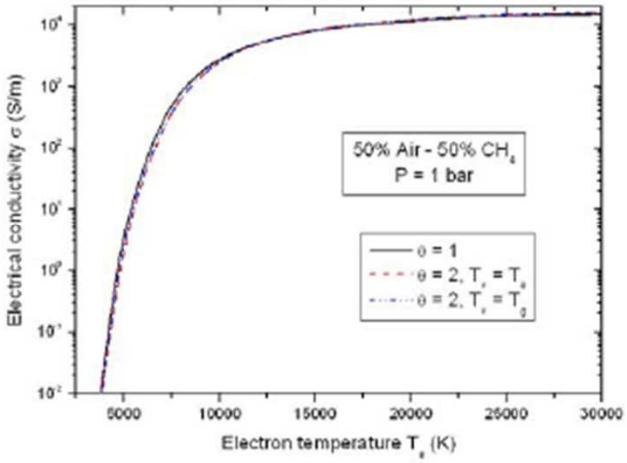
Thermodynamic properties and transport coefficients calculation for two- temperature air methane plasma, *Dhouidoui R. & al*

Points spécifiques :

Calcul de propriétés 2 températures

- Difficulté sur le choix des température dans les lois d'action de masse et le fonction de partition
- Deux températures (Te et Tg) mais aussi la vibration
- Etude de deux cas. Tv=Te ou Tv=Tg



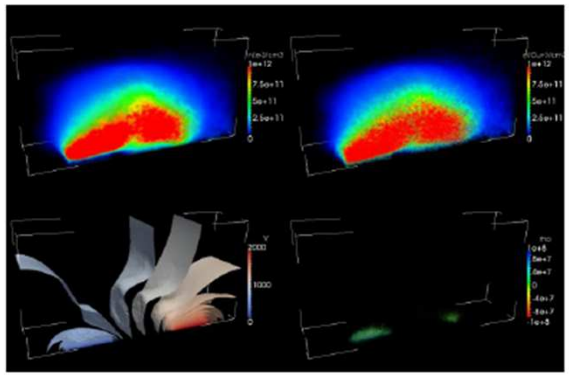


Obtention d'un jeu de données à 2T pour air Méthane, étude de l'influence sur les choix des températures dans la loi de dissociation

Challenges to simulating vacuum arc discharge, *Hopkins M. & al ()*

Sujet principal : Modélisation de décharge d'arc dans le vide

The full vacuum arc discharge process is extremely difficult to simulate. The spatial, temporal, and model capability demands are enormous. The simulation must evolve from an initial collisionless vacuum (or near vacuum) state through a sputtering phase with surface interaction and low collisionality and ionization, into a growing quasi-neutral plasma with increasing collisionality and ionization, to an explosive growth electron avalanche process, and finally to a steady current-carrying arc plasma. The modeling demands change drastically as each of these phases is encountered. We describe a number of model advances to manage the great ranges of plasma density, spatial resolution, and temporal resolution required to simulate the entire breakdown process: dynamic particle weighting, adaptive per-particle and global time stepping, multiple mesh resolutions, and quasi-static time advancement.



Challenges to simulating vacuum arc discharge, *Hopkins M. & al ()*

Points spécifiques :

Modèle développé

- Essai de description de toutes les phases, du breakdown à l'arc

- Utilisation d'un outil de simulation "ALEPH" qui combine de l'électrostatique, maillage instructuré, et du PIC/DSMC pour la cinétique

- Explication des différentes options pour prendre en compte les différentes échelles de temps

Peut être intéressant mais encore dans une phase très prospective

Simulating AC current transfer through near electrodes layers in very high pressure arcs by means of COMSOL Multiphysics, *Almeida N. & al ()*

Sujet principal : Modèle de cathode sur un arc AC de xénon et mercure

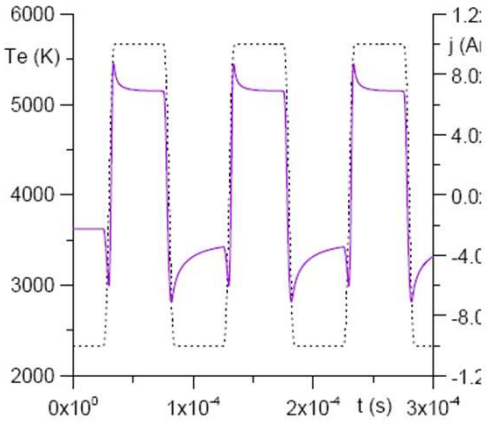
Numerical simulation of AC current transfer through near-electrode layers in very-high pressure arcs in mercury and xenon is reported. The simulation is performed by means of a numerical model in which the whole of a near-electrode layer is simulated in the framework of a single set of equations without simplifying assumptions such as thermal equilibrium, ionization equilibrium, and quasi-neutrality. The system of equations includes equations of conservation of each species (the atoms, ions and electrons), transport equations for each species, equation of energy of the heavy species (the atoms and ions), equation of energy of the electrons, and the Poisson equation. The system of equations is solved numerically in 1D by means of a non-stationary solver of COMSOL Multiphysics.

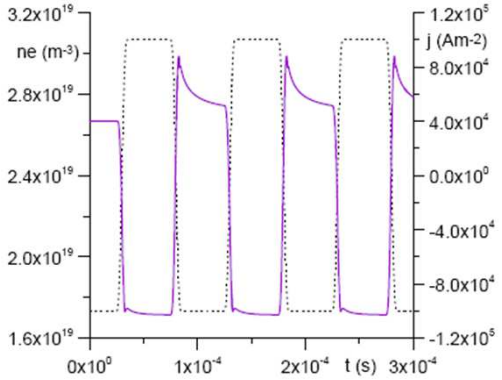
Simulating AC current transfer through near electrodes layers in very high pressure arcs by means of COMSOL Multiphysics, *Almeida N. & al ()*

Points spécifiques :

Modèle développé

- Modèle avec résolution couplée de
  - Equation d'espèces
  - Equation d'énergie, de poisson
- Application dans un modèle 1D COMSOL en AC
- Données d'entrée = J, température électrode et flux nul
- Données de sortie = ne, Te, Th, U

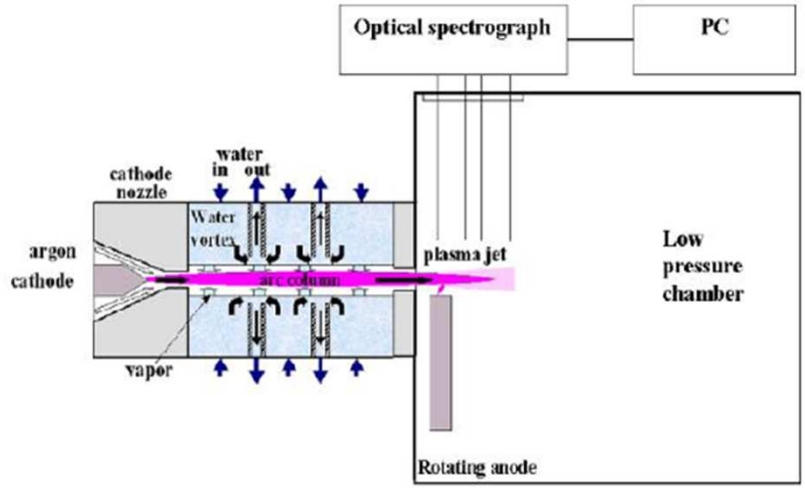




Les derniers développement du modèle de Benilov, avec utilisation de COMSOL

Sujet principal : Mesure de température rotationelle de OH dans une torhe à eau

Emission spectra of OH radical are studied in the plasma jet generated by the plasma torch with hybrid water-argon stabilization. Plasma jet is located in a chamber with pressures 4 kPa and 10 kPa. In spite of high temperatures of produced plasma, OH spectra are observed in a large area of the jet. OH spectra are used to obtain rotational temperatures from the Boltzmann plots of resolved rotational lines. Due to line-of-sight integration of radiation, interpretation of the temperatures is not straightforward. It seems that excited OH molecules can be formed by various mechanisms, mainly in the outer parts of the jet, where thermal processes are not as dominant as in the hot central region.



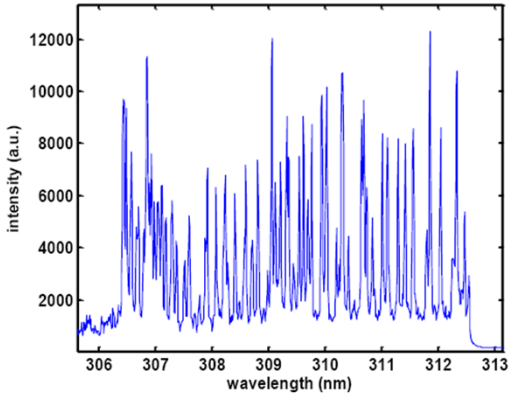
Measurement of OH emission spectra in thermal plasma water – argon thermal plasma generated by the DC plasma torch, Sember V & al

Points spécifiques :

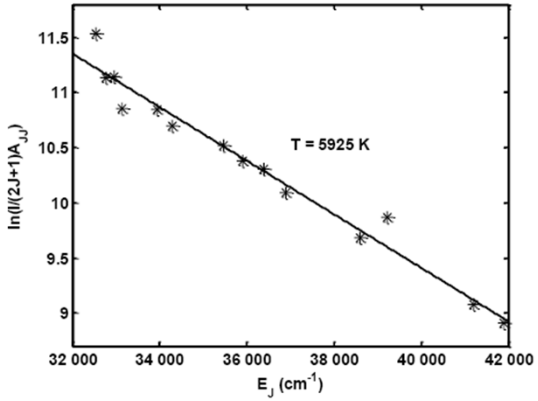
Mesures réalisées

- Mesures des têtes de bandes de OH avec une chambre à 4kPA ou 10kPA

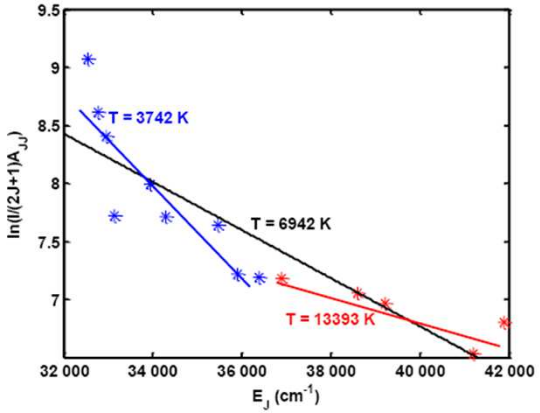
Spectre



Au centre



Sur les bords

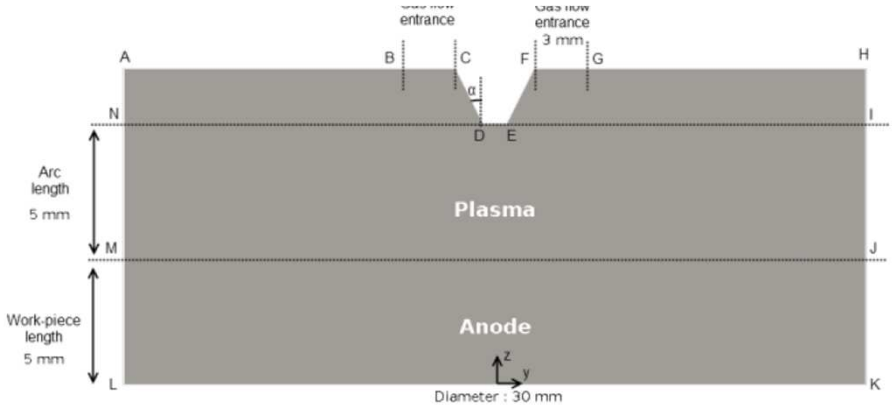


Mesures au centre Ok mais à prendre avec précaution sur les bords

Influence of the plasma gas in TIG configuration, *Mougenot J,. & al*

Sujet principal : Modélisation de l'intération arc anode, Comparaison TIG argon/arcal

The aim of this study is to present the influence of the gas nature in a *tungsten inert gas* (TIG) configuration. A *three dimensional* (3D) CFD transient model of a transferred arc in interaction with an AISI 304 HS work-piece is used to describe the characteristics of the plasma and of the weld pool. The model based on a finite volume method is developed using @Saturne. It includes the plasma, weld pool and the metallic vapors in a same calculation domain. In this work, argon and Arcal 37 (70% He and 30% Ar per mol) plasmas are compared after 1 s of arc ignition for a distance between the two electrodes of 5 mm and an applied current intensity of 200 A with a stationary torch. Due to the difference of heat transfer between the plasma and work-piece, the metallic vapors distribution and the depth-to-width ratio of the weld pool (d/p ratio) are changed following the nature of plasma.

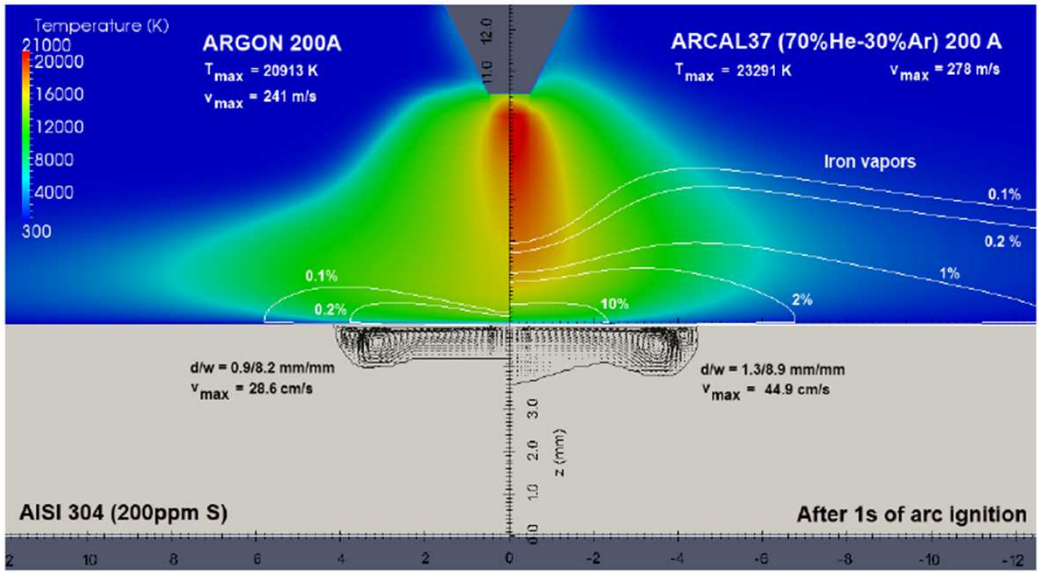


Influence of the plasma gas in TIG configuration, *Mougenot J,. & al*

Points spécifiques :

Modèle développé

- Modèle 3D avec Code Saturne
- Prise en compte de la phase liquide et des forces dans l'anode
- Importance des vapeurs lors de l'interaction



Prédiction des mouvements de métal liquide dans l'anode, différences Argon/arcal, Influence des vapeurs

CONCLUSION

Sujet traités

- **Disjoncteurs haute tension**
- **Problèmes aux électrodes**
- **Déséquilibres thermiques**
- **Synthèse de nanotubes**

Pas beaucoup de plasmas thermiques, de moins en moins adapté à notre communauté

Prochain ICPIG en Roumanie à Iasi