Modeling Stimulated Brillouin Scattering from two smoothed laser beams crossing at large angle.

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In inertial confinement fusion (ICF), stimulated Brillouin scattering (SBS) is a major concern in both direct- and indirect drive schemes as it leads to the backscattering and deflection of the laser beams. In such experiments, the laser beams are optically smoothed with random phase plates (RPP) which produce a wide and relatively flat (intensity-wise) laser spot with structures a few wavelengths wide (the speckles) in which the laser field is coherent.
One strategy, known as polarization smoothing (PS), to limit the growth of laser plasma-instabilities (LPI), is to split the laser beam between beamlets with orthogonal polarization states and uncorrelated phase patterns. The effect of PS on SBS was investigated in 2021 at LULI [1] in an experiment in which a 1.1 ns long $1\,\omega$ laser beam with a mean intensity of a few 10^{13} $\mathrm{W.cm^{-2}}$ interacted with a 8 % n_c preformed nitrogen plasma ($T_e \sim 270$ eV and $T_i \sim 80$ eV). Among other results, the SBS threshold and SBS reflectivity respectively increased and decreased thanks to PS under these plasma conditions.
In a recent follow-up to this experiment, the SBS reflectivity of two RPP smoothed 1ω laser beams propagating with a large relative angle of incidence (50°) and overlapping in an helium gas jet was studied depending on the lasers mean intensity and relative linear polarization states. The flow of the plasma was orthogonal to the plane of incidence of the lasers.
To support this investigation, we have carried out preliminary simulations with our LPI non-paraxial envelope simulation code HYZAK [2] in 2D. The incident laser field of the two beams is computed using the LMJ_FOC code [3] based on the LULI RPP parameters. The beams are propagated during a few tens of ps in a 280 µm long fully ionized helium plasma with plasma parameters given above.
In a first set of simulations including a single RPP beam and different mean intensity values, we recover the experimental intensity threshold for strong SBS reflectivity. Then, adding a second RPP beam with a 50° relative incidence angle, we show that, under these conditions, the SBS reflectivity of each beam does not change significantly due to the presence of the other irrespective of their relative polarizations. This result agrees with a preliminary analysis of the experimental data. Finally, we repeat two beams simulations with collinear polarizations and smaller incidence angles and identify a maximum angle for significant SBS interaction involving the two beams.

Preference: poster

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Differentiation of alpha particles from carbon ions using various types of solid-state nuclear track detectors

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Solid-state nuclear track detectors (SSNTD) have been used widely in the last decades to measure the yield of nuclear reactions occurring in laser-plasma experiments. Their cost and ease-of-use (despite being time consuming) made them popular for particle emission measurements down to the single particle precision.
Another of their advantages compared to other diagnostics, particularly to Thomson parabola spectrometers (TP), is that SSNTD can be used to discriminate particles with the same charge-to-mass ratio. TP do not allow for this, which is a big issue in the context of laser-driven production of α particles, where ions (e.g. C6+ ions) are often produced in larger amount than α particles.
SSNTD allow for such a discrimination through extensive processing and approximations. Indeed, the best technique to date consists in spotting different populations of nuclear track sizes, which are then assumed to correspond to different ion species. This method however brings non-negligible margins of error, hence any method to reduce those is worth investigating.
Although in the last years essentially only CR-39 plastic has been used as SSNTD, PET and polycarbonate can also be used as SSNTD, and some studies suggest that they might have different sensitivities to carbon and oxygen ions. This difference in sensitivity can be used to differentiate the different ion species and measure their respective proportions more precisely.
To check whether this conclusion also applies to carbon ions and α particles differentiation, we conducted an experiment at the CMAM accelerator (Madrid, Spain). There, we exposed a set of PET and polycarbonate samples to a carbon ions flux, and another set to an α particles flux. Then both sets were processed in the same conditions. For comparison we also exposed and processed CR39 foils. This presentation discloses the results from this experiment.

Préférence: poster

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Symétrie 3D d'implosion FCI sur LMJ

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Cette présentation se concentre sur la restitution par simulation numérique tridimensionnelle (3D) d'une expérience de fusion par confinement inertiel (FCI) réalisée en 2024 au Laser Mégajoule (LMJ).
Depuis plusieurs années [1], des expériences de FCI ont lieu au LMJ, chacune augmentant en complexité avec la montée en puissance et l'arrivée progressive des nouvelles chaînes laser au LMJ.
En 2024, la campagne expérimentale mettait l'accent sur l'étude de la symétrie d'implosion en utilisant plusieurs chaînes laser, une approche cruciale pour optimiser la compression uniforme de la cible. Complétant alors les campagnes précédentes avec l'étude de nouvelles formes de cavité afin de sélectionner la plus optimale pour les années à venir.
Malheureusement des aléas expérimentaux ont fait qu'il manquait un quadruplet laser sur vingt à chacun des tirs. Dans ce contexte, les simulations 3D, à l'aide du code TROLL [2], jouent un rôle essentiel dans l'analyse de ces expériences complexes, permettant une modélisation précise des interactions laser-plasma et de l'hydrodynamique de la cible.
Les résultats des simulations seront comparés aux données expérimentales obtenues, soulignant les défis et les succès rencontrés. Cette étude vise à améliorer notre compréhension des phénomènes physiques en jeu et à guider les futures expériences au LMJ.

Préférence: poster

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Sensibilités des écoulements d’ablation à des variations de densités de l’ablateurs

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La stabilité hydrodynamique des flux d’ablation constitue un enjeu majeur dans la fusion par confinement inertiel (ICF) induite par laser, où l’on attend qu’une implosion suffisamment symétrique d’une capsule sphérique permette d’atteindre la combustion thermonucléaire. Lors de la phase initiale de l’implosion, ou phase de transit du choc, les asymétries d’illumination et la rugosité initiale de la surface externe ont depuis longtemps été identifiées comme des sources critiques de perturbations [1]. Plus récemment, des résultats expérimentaux et numériques ont montré que des perturbations internes de l’ablateur pouvaient expliquer la dégradation des performances de la capsule, soulignant la nécessité d’une compréhension approfondie des mécanismes de croissance des perturbations associés [2]. La simulation des effets de modulations de densité enfouies à différentes profondeurs dans une coque a mis en évidence l’importance des interactions entre ondes acoustiques et tourbillons avec le front d’ablation durant la phase de transit du choc [3].

Dans ce travail, nous appliquons une méthode d’analyse de stabilité non modale pour déterminer les distributions optimales de densité au sein d’un ablateur. L’écoulement de base choisi est représentatif de l’ablation radiative d’une coque de capsule durant le passage de la première onde de choc de l’implosion [4]. Des distributions optimales de perturbations linéaires de densité sont calculées pour des longueurs d’onde comprises entre 1 et 100 µm, jusqu’à la percée du choc. Pour chaque longueur d’onde transverse et instant considéré, les distributions longitudinales couvrent l’ensemble du spectre de longueurs d’onde. Une première série de résultats, maximisant l’énergie des perturbations, met en évidence l’interaction constructive de distributions longitudinales à large bande comme un mécanisme significatif de croissance de perturbations à temps fini, particulièrement pour les plus courtes longueurs d’onde transverses. Une analyse physique plus poussée de ces résultats, ainsi que de ceux maximisant les déformations de la couche d’ablation, sera présentée en termes de modes de Kovásznay, de contributions à l’énergie des perturbations et de variables pseudo-caractéristiques [5].

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Etude numérique de l'impact des paramètres d'irradiation laser sur la conversion X de différents matériaux

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La conversion de l'énergie laser absorbée en émissions X dans un plasma est un phénomène fondamental pour l'attaque indirecte dans le cadre de la fusion par confinement inertiel (FCI). Cette conversion est décomposable en deux processus : l'absorption de l'énergie laser et sa ré-émission sous forme de rayons X. La conversion X a des applications dans de nombreux autres domaines comme la production de sources X et la lithographie.

Dans ce travail, une approche numérique basée sur l'utilisation du code d'hydrodynamique radiative TROLL a été mise en place pour décrire les impacts des paramètres d'irradiation de cible (flux laser Φ_L, longueur d'onde λ_L, angle d'incidence θ, etc) et de composition de la cible (numéro atomique du matériau Z) sur l'absorption et la ré-émission X. La représentation des données présentée ici vise à décomposer les effets sur la conversion X des modèles physiques nécessaires à la description de l'absorption et de la ré-émission (modèles d'absorption par Bremmstrahlung inverse, flux de conduction électronique). La comparaison des prédictions provenant des simulations avec des observations expérimentales passées mène à un accord qualitatif et des questionnements sur l'utilisation d'autres modèles pour améliorer cet accord.

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Transport dans les milieux hétérogènes aléatoires

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Mots-clés : Levermore-Pomraing – Milieu stochastique – Modèle à mémoire

Les problèmes de transport dans un mélange aléatoire composé de deux matériaux sont rencontrés dans différents domaines de l'ingénierie nucléaire, notamment dans la fusion par confinement inertiel [1] ou encore dans la physique des réacteurs [2]. Le modèle de Levermore-Pomraning (LP) a pour principe de résoudre un système d'équations de transport couplées pour chacun des deux matériaux [3]. C'est un modèle exact en l'absence de collisions, mais inexact en présence de collisions. Pour pallier ce défaut, il existe des modèles dits à effets mémoire [4-7]. Leur principe consiste à sauvegarder un nombre d'interfaces le long de la trajectoire de chaque particule. Malgré leurs avantages, ces modèles peuvent devenir coûteux en termes de temps de calcul.

Nous présentons une étude basée sur un calcul mono-dimensionnel, qui consiste à modifier le modèle LP de telle sorte à l'améliorer en présence de collisions et à imiter le comportement des modèles à effets mémoire, tout en conservant la simplicité du modèle originel. Nous proposons un nouveau modèle LP modifié, avec des termes supplémentaires qui font apparaître de nouveaux paramètres. Ces paramètres sont optimisés à l'aide d'un code déterministe qui résout l'équation de transport sur un grand nombre de géométries. Avec ces paramètres optimisés, nous arrivons à restituer les observables comme la transmission, la réflexion et les moments (flux scalaire, courant, …) dans différentes configurations. Ce nouveau modèle LP modifié est donc suffisant pour retrouver la plupart des observables, et est ainsi équivalent aux modèles avec un nombre important d'interfaces en mémoire.

Préférence: *Poster (2ème année de thèse)*

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Forum ILP 2025

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Mechanisms at the origin of radio solar bursts by laser-plasma interaction

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Abstract

Solar radio bursts (SRB), linked to intense solar events, are electromagnetic emissions resulting from instabilities (like the Langmuir decay instability) and wave couplings (such as the two-plasmon coalescence). They mainly appear at the plasma frequency (ω_p) and its first harmonic ($2\omega_p$), ω_p being the electron plasma frequency at the source of the emission. Studying these processes provides new perspectives for the understanding of the solar wind and new opportunities for space weather forecast.

Since 2020, experiments (Marquès *et al.*, 2020) at LULI have shown that laser-plasma interactions can replicate most of these processes by generating Langmuir waves via the stimulated Raman instability. This results in the generation of electromagnetic waves at ω_p and $2\omega_p$, similar to the emissions observed during solar bursts. In a forthcoming experiment, we will try to get closer to solar conditions, by introducing a magnetic field to mimic the one of the solar wind. A Particle In Cell (PIC) code (Derouillat *et al.*, 2018) will help us design and interpret this experiment.

In this poster, we will present the basic processes leading to SRB, how they are mimicked in our experiments, as well as the relevant plasma parameters for the two configurations (SRBs and experiment). We will then discuss the typical simulation setups we are envisioning to support our experiments and identify the processes responsible for electromagnetic plasmas at ω_p and its harmonics.

Preference: Poster

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Design of ICF Targets for Energy Production - TARANIS Project

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Abstract

High-gain Inertial Confinement Fusion (ICF) [1] represents a major strategic goal for carbon-free energy production. Recently, the National Ignition Facility (NIF) achieved the first net gain in ICF. In this context, the TARANIS project specifically focuses on optimizing target designs and laser configurations to advance ICF towards practical energy production.
ICF research involves plasma physics, laser-matter interaction, and high-power laser technology. Given the complexity and limited experimental access, high-performance simulations play a crucial role in refining target geometry, laser parameters, and energy output predictions.
To effectively analyze simulation results, a set of diagnostic parameters [2] was first established in post-processing. This framework enabled a systematic optimization study across different target designs, such as dynamic shell scheme [3] and layered targets. For each configuration, the laser parameters, including the intensity and pulse shape, were varied to maximize the gain of the reaction. Large databases of simulation results were compiled, allowing for detailed performance analysis and trend identification. In addition, a machine learning technique [4] were employed to refine laser profiles and identify trends across extensive simulation datasets, enhancing both design optimization and predictive capabilities.
A major milestone of this research is the upcoming experimental campaign at the Laser Mégajoule (LMJ), where we will conduct the first high-energy dynamic shell experiment in a polar-drive configuration. This unprecedented experiment will provide crucial validation of our simulation results and further refine our predictive models for ICF performance. The combination of high-fidelity simulations, AI optimization, and large-scale experimental validation represents a significant step toward achieving high-gain fusion.

Préférence : oral

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Ondes de contrainte dans la silice fondue sous irradiation laser femtoseconde

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Les caractéristiques dynamiques des ondes de contrainte générées par un laser femtoseconde sont étudiées au sein de la silice fondue. Les expériences sont menées à l'aide d'une impulsion laser de 360 fs à une longueur d'onde de 1.03 µm, avec des intensités atteignant 5×10^{14} W/cm² (équivalent vide). Un microscope-polariscope résolu en temps est utilisé pour visualiser la formation du plasma ainsi que la propagation des ondes de contrainte.

Un modèle théorique multiphysique et multiéchelle, intégrant la dynamique électronique, la propagation du laser et la réponse hydrodynamique du matériau, est validé expérimentalement. Ce modèle permet d'obtenir un aperçu détaillé de l'état thermodynamique local du milieu irradié et d'évaluer quantitativement l'influence des différents mécanismes de relaxation de l'énergie laser.

Préférence: poster

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Numerical studies of intermediate-field laser-plasma interaction on the Laser Mégajoule

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In Inertial Confinement Fusion (ICF) experiments performed on the Megajoule Laser (LMJ) facility, intense laser beams are focused into a gas-filled cavity, which is rapidly ionized. When these beams propagate into the resulting plasma, various laser-plasma instabilities such as Forward Stimulated Brillouin Scattering (FSBS) or self-focusing may occur and may then complicate the path to achieving fusion. To mitigate these instabilities, optical smoothing techniques have been used for several decades on large-scale laser facilities. These techniques break both the spatial and temporal coherences of the laser pulses, reducing the coherence lengths and times of the laser beams to values smaller than instabilities thresholds.
While most studies of laser-plasma interactions deal with ideal scenarios, e.g. considering homogeneous plasmas and/or remaining close to the laser focus, our work aims to investigate how the development of instabilities is modified at non-negligible distances from the laser focus. A first step in our work consisted in analyzing the evolution of the statistical properties of the speckles, such as their width, length, and orientation, throughout laser propagation in a vacuum. We used several numerical codes: LMJ-FOC, that calculates the electromagnetic fields produced by various smoothing techniques; PARAX, that describes the propagation of a smoothed laser beam through a plasma within the paraxial approximation; and DSPEC, that extracts the statistical properties of the laser beam from the paraxial simulations.
We studied three configurations in the near field: a Gaussian beam, a square beam, and the quadruplet (quad) beam typical of LMJ, focusing in particular on the speckle properties in a transverse plane located far downstream or upstream from the laser focus. For the Gaussian beam, our simulations reveal a weak correlation between speckle width and the (transverse) distance from the center of the beam. This result is well-established by the so-called Gaussian-Schell model [1]. In contrast, for both the square and quad configurations, we observe a clear correlation between the speckle width and the distance from the beam center, which disappears only near focus. This result is important for modeling laser-plasma interaction over large scales, as envisioned in ICF experiments.

Préférence: oral/poster

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Influence of collisionnal effects and plasma mixtures on stimulated Brillouin backscattering in the kinetic regime

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Indirect-drive inertial confinement fusion (ICF) experiments conducted at the National Ignition Facility and the Laser Megajoule have reported high levels of Brillouin reflected light. To mitigate the growth of the backward stimulated Brillouin scattering (BSBS), it was proposed to include mixtures to enhance the damping rate of ion acoustic waves (IAW). By means of particle-in-cell (PIC) simulations and a kinetic analytical model, including non-Maxwellian inverse Bremsstrahlung heating and collision-induced anisotropy, we revisit the BSBS within laser-heated ICF plasmas. We show that collisional effects substantially affect the IAW properties and so does the amount of Brillouin reflected light. For a laser-created collisional gold plasma, the Langdon effect dominates over Coulomb collisions effect. Therefore, the IAW damping rate becomes smaller than the Landau damping rate, which causes an enhancement of the reflectivity, compared with a collisionless plasma. For a gold-boron plasma, the ion interspecies collisions enable to maintain a significant ion damping and thus, to prevent kinetic inflation. In addition, Adding boron alters the dominant non-linear saturation mechanism. Analytical fits of BSBS instantaneous reflectivity as a function of laser intensity are derived and compared with PIC simulations results.

Préférence: **poster**/oral (sous réserve de l'acceptation d'une présentation orale par le comité)

Data-Driven Nonlocal Heat Transport Modeling in Plasmas Using Neural Networks

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Accurately modeling nonlocal electron heat transport is critical for advancing simulations of high-energy-density plasmas, including those relevant to inertial confinement fusion and astrophysical systems [1]. Classical models such as Spitzer–Härm [2] and nonlocal formulations like Luciani–Mora–Virmont [3] fail under strongly nonlocal conditions, where the electron mean free path approaches or exceeds the temperature gradient scale length. To overcome these limitations, we propose two neural network approaches, each offering distinct advantages for modeling nonlocal transport.

The first approach employs a Convolutional Neural Network (CNN) trained on kinetic simulation data [4]. Using the initial ratio of electron mean free path to temperature gradient length as input, the CNN predicts the spatiotemporal evolution of heat flux. It is fast to train and delivers accurate predictions, but, like most data-driven models, it functions as a black box with limited interpretability of the underlying transport physics. The second approach employs a Conditional Neural Network (cNN) trained to learn the nonlocal heat flux kernel as a function of key physical parameters. This method enables the construction of a dynamic, physics-informed kernel that can accurately reconstruct the heat flux across space and time. While more computationally expensive to train, the cNN offers greater interpretability and a clear connection to the physical structure of the nonlocal transport process, making it a valuable tool for deeper analysis and model validation.

Our work demonstrates the value of machine learning in capturing complex, nonlocal behaviors beyond the reach of classical models. It highlights the potential for hybrid modeling strategies in future plasma simulation frameworks.

Preference: oral

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PIConGPU: a fully relativistic particle-in-cell code for a GPU cluster

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PIConGPU [1] is a fully relativistic, manycore, 3D3V particle-in-cell (PIC) code. The Particle-in-Cell algorithm is a central tool in plasma physics. It describes the dynamics of a plasma by computing the motion of electrons and ions using Lorentz equations and the fields in the plasma based on Maxwell's equations.

PIConGPU implements various numerical schemes to solve the PIC algorithm. Its features for the electro-magnetic PIC algorithm include: a Yee-lattice for fields, particle pushers that solve the equation of motion for charged and neutral particles, e.g., the Boris and the Vay Pusher, Maxwell field solvers, e.g. Yee's and Lehe's scheme, rigorously charge conserving current deposition schemes, such as Esirkepov and EZ (Esirkepov meets ZigZag), as well as macro-particle form factors ranging from NGP (0th order), CIC (1st), TSC (2nd), PQS (3rd) to PCS (4th). Additionally, the electro-magnetic PIC algorithm is further self-consistently coupled to classical radiation reaction [2] and advanced field ionization methods [3].

Besides the electro-magnetic PIC algorithm and extensions to it, we developed a wide range of tools and diagnostics, e.g.: online, far-field radiation diagnostics for coherent and incoherent radiation emitted by charged particles, full restart and output capabilities via openPMD [4], including parallel HDF5 and ADIOS, 2D and 3D live view and diagnostics tools and a large selection of extensible online-plugins.

Originally developed to run on NVIDIA GPUs using CUDA, the code has been ported [5] to a variety of other platforms using the Alpaka library [6], including INTEL and AMD architectures. PIConGPU has been used to study plasma processes relevant for advanced particle accelerators, compact laser-driven ion accelerators for medical tumor therapy and astrophysics. PIConGPU and the libraries maintained by HZDR are OSI-approved open source (GPLv3+, LGPLv3+ or MPL2).

Additional informations

Preference: Poster

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A “new” collisionless heating mechanism driven by phase-space filamentation in a counterstreaming beam configuration

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We discuss some numerical experiments simulating the nonlinear dynamics of an oblique instability in a relativistic counterstreaming electron configuration in a collisionless plasma [1,2,4], and some more recent studies conducted along this line.

When the oblique instability is initialized by exciting a wide spectrum of oblique modes that includes a low-frequency branch, recently identified [3] and which displays an important nonlinear electrostatic dynamics [4], a nonlinear turbulent state is achieved. This is characterized by the presence of both electrostatic and magnetic trapping structures, the latter only being typical of Weibel-type instabilities. During this nonlinear stage, a reversal of the initial energy transfer, from magnetic to kinetic energy, which is typical of Weibel type modes, is observed: a kinetic heating process takes place, transforming magnetic energy into kinetic/thermal energy, which is distinct from magnetic reconnection and arguably more "fundamental" than it.

A diagnostics based on the analysis of synchronization of Fourier modes allows us to highlight the relation of this collisionless, kinetic heating with phase space filamentation. We recall that phase-space filamentation is an intrinsic property of transport equations describing the kinetic evolution of a distribution of particles. In a free-streaming case, filamentation is of kinematic nature (see, e.g., Ref. [5], Sec. 5.4). In presence of forces it can be dynamically "enhanced", e.g., by plasma instabilities. This is the case of interest here [1,2].

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Target design and irradiation optimization for stable direct-drive laser fusion implosions

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In laser-driven inertial confinement fusion (ICF), target stability is essential to achieve high compression and ignition. Hydrodynamic instabilities, seeded by laser nonuniformities and target imperfections, can severely degrade implosion symmetry and performance. Polymer foams have emerged as a promising mitigation strategy, modifying plasma conditions at the ablation front and smoothing initial perturbations.

While indirect-drive ignition has been demonstrated at the National Ignition Facility (NIF) [1], no existing large-scale facility is currently optimized for direct-drive fusion. In this context, the Taranis project in France, led by GenF, aims to develop a next-generation direct-drive laser fusion reactor. This approach relies on robust and easily manufacturable targets, where foam-based designs are particularly attractive for reducing imprint and enhancing implosion stability [2,3].

To support this effort, we performed numerical studies of both irradiation symmetry and hydrodynamic stability across multiple scales. Optimization of innovative chamber geometries [4] is carried out using the inverse-ray-tracing code IFRIIT [5], enabling the identification of beam parameters (e.g., super-Gaussian order, spot size) that minimize initial irradiation non-uniformity. The robustness of these configurations is then tested statistically via experimental errors sampling. In parallel, 1D hydrodynamic simulations with the MULTI code [6] explore implosion dynamics and shock timing in foam-based targets, while 2D PIC simulations with SMILEI [7] model laser-plasma interactions within low-density CH foams to quantify imprint generation and energy deposition. These combined approaches offer insight into the design of robust targets for direct-drive laser fusion in the multi-kJ regime.

Préférence: poster

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Momentum space adaptive mesh refinement for Semi-Lagrangian solver to study relativistic Weibel-like instabilities

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A dynamic adaptive mesh refinement (AMR) method, performed only on the momentum coordinates, has been incorporated into the parallelized relativistic 2D2V Semi-Lagrangian (SL) code VLEM (Vlasov ElectroMagnetic solver) [1, 2]. This type of refinement leads to remarkable computational gains, especially during the transient time [3], and is well suited to follow velocity space perturbations of the distribution function, such as heating, acceleration or filamentation processes. Indeed, the SL method requires a large sampling in the momentum space to follow the filamentation process, which is a mathematical property of the Vlasov equation.

The application of SL methods to Weibel-like instabilities (current filamentation instabilities (CFI), two-stream instabilities (TSI) or oblique instabilities (OI)) can lead to the generation of thin filaments in the momentum space associated with energy transfer [4]. The AMR method helps to describe them with less numerical effort. This is particularly important when the temperature anisotropy between the beams is significant, since one needs a wide momentum box to describe the hot beam and a high precision to describe the cold beam. In this way, the AMR method helps to perform numerical experiments that were previously much more difficult, and to reveal the transition from OI to CFI in the regime where the OI growth rate is higher.

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FORUM ILP 2025

Design and optimization of helical coil targets for laser driven proton acceleration

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Laser-driven proton beams have shown strong potential for applications in ultrafast radiography, tumor therapy, and inertial confinement fusion. Compact setups based on the Target Normal Sheath Acceleration (TNSA) mechanism offer a promising route for high-gradient ion acceleration. However, the broad energy spectrum and large divergence of TNSA beams remain key limitations.

Helical coil targets are commonly used to improve beam quality, collimation, bunching, and post-acceleration of TNSA-generated protons [1,2]. These targets rely on a transient current pulse propagating along the helix to generate strong, localized electromagnetic fields that interact with the proton beam in-flight. While effective for collimation, post-acceleration and bunching are often limited due to current dispersion during propagation. Previous studies have shown that enclosing the helix in a guiding structure can reduce this dispersion and enhance bunching [3].

To further improve post-acceleration efficiency, we investigate the optimization of the coil geometry—varying parameters such as pitch, radius, and length to maximize the interaction between protons and the discharge current. Moreover, in standard designs, the coil is physically attached to the TNSA target, meaning each laser shot consumes the entire target–coil assembly and limits repetition rate. We are currently developing a two-laser, two-target configuration: one laser drives the TNSA source, while the second independently triggers the coil discharge. This decoupled setup is designed to support high-repetition-rate operation and modular component reuse.

Préférence: poster

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FORUM ILP 2025

Comportement des nanoparticules sous chauffage par impulsions courtes : Étude des mécanismes atomiques via simulations atomistiques

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Les nanoparticules subissent des transformations complexes sous chauffage par impulsions courtes, ce qui est crucial pour de nombreuses applications en catalyse, science des matériaux et nanotechnologies. Dans cette étude, nous utilisons des simulations de dynamique moléculaire (DM) pour examiner le comportement dynamique de diverses nanoparticules mono- et bimetalliques et/ou leurs alliages, sous excitation thermique rapide. En utilisant le champ de forces réactives ReaxFF, nous explorons des processus tels que le frittage, l'alliage et la fragmentation en présence d'oxydation et d'autres réactions, fournissant de nouvelles perspectives sur les mécanismes au niveau atomique qui régissent l'évolution des nanoparticules. Nos simulations révèlent un ensemble de transitions structurales et de phases gouvernées par les variations pression-température. De plus, les nanoparticules sont montrées vibrer et, lorsque le chauffage dépasse un seuil critique, elles subissent une fragmentation, les particules plus petites subissant des changements plus marqués en raison des effets de surface. L'étude met également en évidence le rôle de la taille, de la composition et des conditions thermiques des nanoparticules, soulignant comment l'alliage et le mélange sont renforcés sous des régimes de chauffage rapide. Les résultats illustrent le potentiel de contrôle des propriétés et de la morphologie des nanoparticules en ajustant les taux de chauffage, la taille des particules et la composition, contribuant ainsi à la conception de nanomatériaux avancés pour diverses applications, y compris la catalyse, les capteurs et le stockage d'énergie. Ces résultats comblent le fossé entre les efforts théoriques et expérimentaux, ouvrant la voie à des stratégies de synthèse optimisées et à de nouveaux matériaux à base de nanoparticules.

Préférence: poster/**oral** (sous réserve de l'acceptation d'une présentation orale par le comité)

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