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POSTER ABSTRACTS

OPTIMIZATION-BASED RESIDENTIAL LOAD SCHEDULING TO IMPROVE RELIABILITY IN THE DISTRIBUTION GRID

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Despite the recent rapid adoption of rooftop solar PV for residential customers, islanded operation during grid outages remains elusive for most PV owners. In this paper we consider approaches to improve the reliability of electricity supply in the context of a residential microgrid, consisting of a group of residential customers each with rooftop solar PV, that are connected to the distribution network via a single point of common coupling. It is assumed that there is insufficient PV generation at all times to meet the electricity demand within the residential microgrid. Three optimization-based algorithms are proposed to improve the reliability of electricity supply to each residential customer, despite variability and intermittency of the solar resource and periods of infrequent and sustained power outages in the electricity grid. By means of a case study we show that the majority of residential customers achieve greater reliability of uninterrupted electricity supply when connecting to the residential microgrid in comparison to operating in isolated self-consumption mode.

A COMPUTATIONAL MODELING APPROACH OF USER BEHAVIOR FOR SWARM CONTROL APPLICATIONS

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Our research creates a formal, verifiable computational approach to model the effects human behavior and habits on using different devices that can be integral parts in the new Internet-of-Things (IoT) world. The computational approach creates workloads, quality of service requirements and scheduling paradigms that are borrowed from traditional computing systems and applies them to interactions between humans and IoT devices.

ECO-DAC: ENERGY CONTROL OVER DIVIDE AND CONTROL

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Our research focuses on the optimal control of an energy storage system in small to medium sized power distribution systems with loads and renewable resources. We provide a low-complexity algorithm, ECO-DAC, which is optimal in terms of minimizing a multi-tier cost function. In contrast to the state-of-the-art, we use a high accuracy nonlinear battery model that captures the nonlinear characteristics under high current charging and discharging regimes. We show in case studies that we can save up to 21% in costs for electricity drawn from the grid, compared to the no-battery case. Furthermore, we show that we have a high tolerance to forecast errors for 3 actual buildings from the UCSD campus.

CLOSED-FORM ANALYTIC SOLUTION OF CLOUD DISSIPATION FOR A MIXED LAYER MODEL

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In this work, we build up a physical mixed layer model for stratocumulus clouds in California coasts with radiation, buoyancy flux and surface schemes and use mathematical approximations to obtain a closed-form analytic solution to the cloud dissipation. The advantage of an analytic solution is that the complete dependency and sensitivity are observable directly from equations. As an example, we can directly infer how the cloud thickness is going to be affected depending on the changes in Bowen ratio, given the initial conditions of the system. More importantly, we can infer how this change is going to evolve in time without using numerical integration methods.

ON THE STRUCTURE OF THE ZONAL SHEAR LAYER FIELD AND ITS IMPLICATION FOR MULTI-SCALE INTERACTIONS

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A theory is presented for the formation and evolution of density staircases and zonal shear profiles in a simple model of drift-wave turbulence. Density, vorticity and turbulent potential enstrophy are the variables of this system. Formation of the staircase structures is due to the inhomogeneous mixing of generalized potential vorticity (PV) resulting in the sharpening of density and vorticity gradients in some regions and weakening them in others. Inhomogeneous mixing of PV is implemented via a nonlinear Rhines scale dependent mixing length. This closes the feedback loop by reducing the turbulent diffusivity. The density staircase structure develops from an initial modulation and evolves into a lattice of mesoscale "jumps", which are regions of locally steep gradients, and "steps", which are regions of gradient flattening. The jumps merge and migrate, leading to the development of macroscale profile structures from the mesoscale elements. We present extensive studies of bifurcation physics of the global state, including results on the global flux-gradient relations (flux landscapes) predicted by the model. Furthermore, we demonstrate that depending on the sources and boundary conditions, either an edge region of enhanced confinement, or an extended edge step, with strong turbulence, can form. This suggests that the profile self-organization is a global process, though one describable by a local, but nonlinear model.

ALLOCATION OF BATTERY ENERGY STORAGE SYSTEMS TO ENHANCE DISTRIBUTION SYSTEMS

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Planning and managing the electric distribution system is becoming more challenging due in part to the widespread adoption of rooftop solar photovoltaic (PV) systems. Grid reinforcement is required to keep the energy network running without operational issues and allowing further increase in PV penetration. Distributed storage is often considered as a viable tool to offset these impacts caused by distributed grid-connected solar PV systems. A methodology for optimal allocation of utility-scale BESS to support high penetration PV integration in distribution systems is presented in this poster. The goal is to optimally size and site battery energy storage systems (BESSs) in a distribution system for maximizing voltage mitigation benefit per unit BESS procurement costs. The optimum BESS configuration is determined by controlling two decision variables: the size of each BESS and the installation point of each BESS. The reduction in voltage deviations at the most-impacted nodes within the network is considered as the value stream of BESS. The methodology is convergent to exact nodes when siting decision is done for small sets. For large sets, the results converge to network regions rather than exact nodes.

DESIGN AND CHARACTERIZATION OF A COMPACT DOUBLE GAS INJECTOR FOR STAGED Z-PINCH

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A Z-pinch is one of the earliest approaches used to study thermonuclear fusion, due to its relatively simple system to compress the plasma: during a pulsed-power discharge in a cylindrical plasma, the self-generated magnetic field is used to compress the plasma by the JxB force. The Z-pinch is able to produce significant yields of nuclear events, for example in the form of X-rays and neutrons.

A Staged Z-pinch is a particular Z-pinch configuration comprised of a high-atomic-number liner, imploding onto a coaxial, lower-atomic-number plasma target. When the outer liner implodes, it scoops in the inner target towards the axis. This äóìstagingäó_ process, where the implosion energy is transferred from one material to another, suppresses the fluid instabilities and is expected to produce a faster, greater compression to favorable thermonuclear fusion conditions.

The presented work involves the design and characterization of a gas-plasma injector to provide optimal initial conditions to launch a staged Z-pinch. The injector produces an annular, high-atomic-number, neutral gas puff co-axially with a target Deuterium plasma. The neutral gas-puff is produced by an annular solenoid valve and a converging-diverging nozzle, designed to achieve a Mach number around M=5 in the annular gas jet. The on-axis, cylindrical plasma is produced by a coaxial plasma gun filled with Deuterium gas ionized by a high voltage discharge.

In order to achieve an optimal implosion, the annular gas and the target plasma must have precisely tuned mass density profiles. The injector design is optimized with the CFD simulation code, Fluent, and using CAD software, while the machining is performed at the UCSD machine shop.

After construction, the nozzle is characterized with optical diagnostics such as laser interferometry and visible light emission detection, and electrical diagnostics such as breakdown pins and Faraday cup measurements to determine the properties of the mass flow.

MEMORY, CASCADES AND SPECTRA IN MODELS OF 2D MHD AND ELASTIC TURBULENCE

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Virtually all models of drift-Alfven, EM, ITG, etc. turbulence are based upon a vorticity equation, Ohm's Law and (usually multiple) scalar advection equations. The appearance of the Alfven wave introduces a crucial element of memory to the dynamics. Such Alfvenization-induced-memory can significantly impact structure formation and transport in turbulence.

In this work, we study the fundamental physics of memory and cascades in very simple models such as 2D MHD and elastic turbulence. The 2D Cahn-Hilliard Navier-Stokes (CHNS) turbulence is a challenging analogue to 2D MHD turbulence. The important similarities include basic equations, ideal quadratic conserved quantities, cascade directions and elastic waves. The domain surface tension induces elasticity, and the balance between surface tension energy and turbulent kinetic energy determines an emergent length scale (Hinze

Scale) of the system. The Hinze Scale may be thought of as the scale of emergent critical balance between fluid straining and elastic restoring forces. The range between Hinze Scale and dissipation scale is defined to be the elastic range of 2D CHNS system, where the elasticity offered by surface tension play a major role, just as the elasticity offered by magnetic field is of central significance in 2D MHD. In the elastic range, the mean square concentration spectrum is H “š äš_ kášÍ7/3. Because the power is the same as the mean square magnetic potential spectrum H A äš_ kášÍ7/3 in the regime of inverse cascade of HA, this result suggests the dominating mechanism for the dynamics of concentration fluctuation is the inverse cascade of H“š. In 2D MHD, a weak mean magnetic field can result in a large mean square fluctuation, and then the strong small scale magnetic fields lead to enhanced memory. The enhanced memory suppresses the turbulent transport. A similar turbulent transport suppression process also occurs in 2D CHNS system. Memory due to elasticity effects is of central importance in regulating the growth of zonal flows and fields in drift-Alfven turbulence. This study elucidates the physics of elasticity-induced-memory in the context of a simple system. The implications for the more complex case of drift-Alfven turbulence will be discussed. This material is based upon work supported by the U.S. Department of Energy, Office of Science, Office of Fusion Energy Sciences, under Award Number DE-FG02-04ER54738.

MODELING TRANSPORT BIFURCATIONS IN CSDX LINEAR PLASMA DEVICE

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A transport bifurcation phenomenon was recently observed in CSDX linear machine: experiments have shown that when the axial magnetic field exceeds a critical value Bcritical=1200G, a global transition in the plasma profiles occurs. Signs of this transition include steepening in the mean density profile of the plasma, formation of a strong azimuthal velocity shear flow layer and a development of a hysteresis loop in the density gradient modulus when a forward/backward scan of the magnetic field was performed near Bcritical. A localized net inward particle flux was also verified experimentally.

Here we explore these experimental results using a 1D numerical model that describes mixing of potential vorticity in a purely diffusive way. Space and time evolution of three plasma fields (density, vorticity and enstrophy) are investigated using a self-consistent model that describes turbulence suppression and flow self-organization in CSDX. The Haswgawa-Wakatani meso scale based model uses a nonlinear expression of the mixing length that depends on the density and vorticity gradients and shrinks as they steepen. The model adopts mixed boundary conditions and validates the experimental results previously obtained which are negative values of the Reynolds work indicating turbulence suppression and energy transfer from small scale turbulent structures to larger scale mean flows, steepening of the density profiles and development of a net inward particle flux. The results suggest the existence of a system dynamic capable of sustaining the plasma core by means of a purely diffusive particle flux. This promotes enhancement of the plasma confinement and generation of transport barriers often associated with LäÊÍH transition phenomena which are known to be extremely beneficial for the plasma fusion community.

ACTIVE CLOUD CONTROL FOR SOLAR ENERGY GENERATING SYSTEMS

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The variability of the solar resource results in higher integration costs than conventional dispatchable resources. When combined, forecasting and storage can mitigate the majority of the short-term variability issues. An alternative approach is to geo-engineer the frequency and optical depth of water droplet clouds that are responsible for the variability in ground level solar irradiance. Active control of cloud cover is beyond current capacity both in terms of scale and of energy requirements. However, there are meteorological phenomena, including both natural (fogs) and anthropogenic (aircraft condensation trails), that affect solar generation at the ground level and that can be controlled with current technologies. The unrealized revenue for a typical power plant due to the solar radiation obstruction at the ground level leaves room to implement new technologies that could fundamentally change the operations of central station plants. Here we examine the use of infrared radiation to evaporate fog droplets. An infrared emitting CO2 laser is used to investigate the total absorption of a low density ensemble of optically thin water droplets.

HIGHLY COLLIMATED QUASI-MONO-ENERGETIC ION BUNCHES ACCELERATED FROM HIGH INTENSITY LASER DRIVEN ULTRA-THIN FILM

Jinqing Yu, C. McGuffey, C. M. Krauland and F.N. Beg
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In order to understand the energetic ions accelerated by an intense laser pulse, we model laser interactions with silicon targets at an intensity of 1020 W/cm2 with field ionization included. The target thickness is varied in combination with the inclusion of target surface impurities. It is observed in all cases that highly collimated quasi-mono-energetic Si+13 and Si+14 ions are accelerated by sheath fields on the target front surface. With impurity layers, we also obtain quasi-mono-energetic O+7 and O+8 ion bunches in both forward and backward directions. The O+8 and Si+14 ions are highly collimated into a spread angle less than 5ŒÁ. The peak energy of the O+8 bunch can reach up to 21 MeV-per-nucleon. The acceleration of highly collimated energetic silicon and O+8 ion bunches is attributed to Target Normal Sheath Acceleration (TNSA) and ionization dynamics.

ADVANCES IN SKY IMAGER SOLAR ENERGY FORECASTING

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Sky imagers are a well-accepted technology for producing short-term forecasts of solar energy availability. Here, we present three recent developments at UCSD that we anticipate will improve accuracy of sky imager forecasts in the future.

The first is a method for retrieving cloud optical depth based on an image's red channel radiance and red-blue ratio (RBR). Based on a library of Radiative Transfer simulations, the image's red radiance will generally correspond to one of two possible optical depths; this ambiguity is then resolved using the image's RBR. The RRBR method was applied to 220 days of images and validated against results from a microwave radiometer (MWR) and another method based on global horizontal irradiance (GHI) due to Min et al. Detected optical depths ranged from 0 to 80, with RMSE of 2.5 vs the Min et al. method, and 2.2 against the MWR.

The second technique allows measurement of direct normal irradiance (DNI) using CCD smear, which is otherwise considered an undesirable feature of CCD sensors. A filtering process measures the level of smear in a raw image, which is then calibrated to produce a DNI measurement. Combined with the camera's ability to measure diffuse irradiance across the remainder of the sky, this permits measurements of GHI, which a one-year study found to have RMSE of 10% compared to a reference sensor.

The final technique uses a novel device dubbed a cloud shadow speed sensor (CSSS) to measure the speed and direction in which clouds are moving. Because image-based cloud velocity measurements depend on cloud height, this measurement permits determination of the cloud height, which is a critical parameter in geometrical cloud position forecasts. Based on two months of data, root-mean-square difference (RMSD) of estimated cloud height vs an on-site ceilometer was 126 m, or 17%.

ON THE PHYSICS OF INTRINSIC FLOW IN PLASMAS WITHOUT MAGNETIC SHEAR

Li, Jiacong; Hong, Rongjie; Diamond, Patrick H.; Tynan, George R.; Thakur, Saikat C.; Xu, Xueqiao
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Enhanced confinement states in tokamaks require a combination of toroidal rotation and weak magnetic shear. Intrinsic rotation in weak shear regime is of particular interest since rotation driven by external torque is insufficient for ITER. Interestingly, the controlled shear de-correlation experiment (CSDX), a linear device at UCSD with uniform axial magnetic field, is a promising testbed for studies of intrinsic flows in such regimes without magnetic shear. We report on synergistic theory and experiments which investigate intrinsic flows in magnetic shear-free regimes. We propose a simple model to understand intrinsic axial flow generation at the confinement transition in CSDX. This involves a new dynamical symmetry breaking mechanism using a simple model of electron drift wave turbulence in the presence of axial flow shear. This mechanism does not require a particular magnetic field structure (e.g. shear) and thus is also applicable to intrinsic rotation generation in tokamaks at weak or zero magnetic shear. The mechanism is essentially the self-amplification of the axial flow profile, i.e. a modulational instability, driven by electron drift wave turbulence. Hence, the flow profile development is due to a form of negative viscosity phenomenon. Unlike mechanisms familiar in the context of intrinsic rotationäóñwhere the residual stress produces an intrinsic torqueäóñin this dynamical symmetry breaking scheme, the residual stress induces a negative momentum diffusivity correction, in response to the test flow shear. The axial flow gradient is amplified by this negative viscosity increment. In order to understand the significance of this mechanism for tokamak rotation, itäó»s useful to make an analogy to turbulent pipe flow, where the flow shear is set by a competition between axial pressure drop and turbulent viscosity. For intrinsic rotation in tokamaks, a related synergy of the familiar mechanism of residual stress and dynamical symmetry breaking is proposed. This material is based upon work supported by the U.S. Department of Energy, Office of Science, Office of Fusion Energy Sciences, under Award Number DE-FG02-04ER54738.

SOLAR FORECASTING FOR LARGE-SCALE SOLAR PLANTS

Li, Mengying; Chu,Yinghao; Larson, David; Pedro, Hugo; Coimbra, Carlos
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Accurate and reliable generation forecasts are very important for the operation of large-scale solar plants. Good forecasts can reduce plant operation costs associated with intra-day variability, reduce imbalance charges incurred by solar plants due to inaccurate forecasts, reduce utility costs associated with day-ahead scheduling (thereby reducing overall solar O&M costs), and assist the grid operator to balance load demand schedules.

In this poster we present our experience in creating solar resource and solar generation forecasts for two large solar farms (a 250 MW PV plant and a 392 MW CSP plant) in California.

We present some typical results that can be obtained by applying the latest research models in a real-case scenario. We also highlight the major hurdles that must be addressed to increase the forecast accuracy. Finally we describe some tools under development to overcome these hurdles.

SHOCK WAVE FORMATION IN A STAGED Z-PINCH: A COMPARISON OF Ne, Ar, Kr, AND Xe ON DD GAS PUFF IMPLOSIONS

Narkis, Jeff; Rahman, Hafiz Ur; Ney, Paul; Beg, Farhat,
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The resistive MHD code MACH2 is used to simulated Staged Z-pinch, gas-puff implosions of Ne, Ar, Kr, and Xe shells onto a DD target. The fundamental concept of the Staged Z-pinch is target separation from the outer surface of the shell, which is inherently MRT-unstable. 1-D simulations show stronger (magnetosonic Mach number, M_M äŠš 2) shocks in Ne and Ar than in Kr and Xe (M_M äŠš 1.2-1.3), with the shock appearing earliest (100 ns) in Ne, followed by Kr/Xe (120 ns), and Ar (140 ns). The difference in resistivity between materials is proposed as an explanation of this behavior. 2-D simulations investigate MRT (magneto-Rayleigh-Taylor) instability development. Results suggest there is an ideal degree of target separation; either too much or too little results in a thinner effective length scale for MRT instability growth.

FORECASTING THE SOLAR RESOURCE: WHAT CAN WE DO? HOW CAN WE IMPROVE?

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Research groups throughout the world have developed forecast models with the objective of reducing the uncertainty in solar energy generation. These models can be useful in many situations from short term energy trading to day-ahead resource scheduling. As such they must perform well for a wide range of forecast horizons, from few minutes out to several days into the future. In this poster we give an overview of the state-of-the-art in variable generation forecasting. We highlight what can be accomplished presently and discuss areas where improvements are required. In particular we identify bottlenecks that prevent increasing the forecast performance and present some diagnose tools that can be used to study the quality of the solar forecasts.

INTRA-HOUR TO DAY-AHEAD GLOBAL AND DIRECT SOLAR IRRADIANCE FORECASTS

Pedro, Hugo; Coimbra, Carlos; Larson, David
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In solar energy literature one can find the bits and pieces necessary to create solar irradiance forecasts that cover time scales ranging from intra-hour to days-ahead.The caveat is that rarely these models cover more than a single time scale making them unattractive to solar power producers that require accurate forecasts for all time scales. Thus, in this work we present a framework that can be used to create direct and global irradiance forecasts for intra-hour, intra-day and days-ahead in real time. The methodology presented uses ground telemetry, local sky images (if available), satellite images and the output of numerical weather predictions (NWP) models. Given that ground telemetry must be available and satellite images and NWP data are freely available for the entire US territory this methodology can be applied to any location of interest. Furthermore, the proposed methodology uses different figures of metric depending on the forecast horizon. For instance, in the intra-hour time scale the goal is to predict large ramps in irradiance and not bulk error metrics such as the RMSE or MAE. This methodology is applied to locations in California with varying climates in order to assess its performance.

STUDY OF PULSE LENGTH IMPACT ON HOT ELECTRON TAIL GENERATION IN HIGH INTENSITY LASER PRE-PLASMA INTERACTIONS

Peebles, Jonathan
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Relativistic laser plasma interactions (LPI) has developed as a source for potentially interesting and useful applications, such as table top particle acceleration, electron positron pair production and high energy K-alpha and gamma ray sources. In the case of electron acceleration, sections of the electron spectrum are generated by different mechanisms which can be controlled by altering the laseräó»s intensity, pulse length or pulse shape. Recently it has been shown that a pre-plasma on the target surface, generated by laser pre-pulse, plays an important role and increases the average energy of generated electrons. To examine this we utilized the split beam short pulse (0.7 äóñ 5 ps) capability of the Titan system; one beam component interacted with a simple multilayer metal foil target to generate high energy electrons, the other impacted a secondary foil to generate protons normal to the main multifoil interaction. These protons were used to radiograph the interaction of the short pulse with a pre-formed plasma generated by a 3 ns, 0 äóñ 150 J, wide focus long pulse beam. Several features were seen evolving in time in the radiographs including forward propagating waves and large electrostatic fields. The characterization of these features and supporting PIC simulations will be main subject of the poster. This information will be supplemented by measurements taken by electron and bremmstrahlung spectrometers.

BROADBAND PROTON RADIOGRAPHY OF SELF-GENERATED FIELDS IN STRONGLY-SHOCKED, LOW-DENSITY SYSTEMS

Rui, Hua; H. Sio; Y. Ping; S. C. Wilks; C. Mcguffey; F. N. Beg; G. W. Collins
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In shock convergence stage, the physics of shock front area, which is characterized by abruptly increasing temperature and ion-ion mean free path, is governed more by kinetic effect instead of pure hydrodynamic [1]. The existence of a self generated electric field across shock front has been brought up since 2008 and the First direct observation was achieved from an implosion experiment [2]. This field potentially plays a significant role during shock converging period and multiple implosion experiments were conducted for further investigation. In this presentation, a quasi-planar platform using TNSA probing proton to study shock front in low density gas system is reported. This experiment was conducted on OMEGA EP using three long pulse laser beams with a total energy of 6 kJ in 2ns for shock generation and an 850 J, 10 ps short pulse laser for proton generation. Direct evidence for the existence of the electric field at shock front was detected by Radiography Films and a quantitative measurement of the electrical potential, which is around 1.5 kJ by calculation, is achieved for the first time.

[1] Rosenberg M J, Exploration of the Transition from the Hydrodynamiclike to the Strongly Kinetic Regime in Shock-Driven Implosions[J], Physical review letters, 2014, 112(18): 185001.

[2] Li C K, Monoenergetic-proton-radiography measurements of implosion dynamics in direct-drive inertial-confinement fusion[J], Physical review letters, 2008, 100(22): 225001.

ASSIMILATING IN-SITU OBSERVATIONS OVER SOUTHERN CALIFORNIA FOR IMPROVED SOLAR FORECASTING

Sahu Dipak Kumar, Zhong Xiaohui, Kleissl Jan
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Integration of forecasting of solar energy feed- in to the electric network is becoming essential because of its continually increasing penetration level. Three-dimensional numerical weather prediction (NWP) models predict the weather based on the current weather conditions (called initialization) and simulate of the ensuing atmospheric processes. The accuracy of forecasts therefore depend, in part, on the accuracy of the model initializations. Data assimilation is recognized as the most widely used technique to improve the initialization into NWP models. In specific, meteorological observations from the surface and upper-air in-situ networks over the southern California coast are assimilated into the Weather Research and Forecasting (WRF) model. It is found that the global horizontal irradiance (GHI) produced by WRF data assimilation experiments are significantly closer to the observations as compared to the standard WRF forecast. Especially, the GHI biases are reduced significantly during the morning hours.

SYNTHETIC DIAGNOSTICS OF PLASMA TURBULENCE MODEL WITH APPLICATION TO MAGNETIC CONTROLLED FUSION

Vaezi, Payam, Holland, Christopher, Tynan, George, Thakur, Saikat Chakraborty
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Turbulence is a ubiquitous phenomenon in fluids that has been recognized and studied for a long time. It is often called the last unsolved problem in classical physics, mainly because we cannot predict in detail how or why turbulence occurs or fully predict its behavior. However, it is extremely important to gain an understanding of it in laboratory plasmas and magnetically confined fusion devices because it causes increased particle and energy transport. For instance, very good particle confinement is needed in Tokamak scrape-off-layer but not in the core. Better understanding of plasma turbulence leads to better prediction of future devices performance. At the moment, most of our knowledge gained in fusion experiment is based on assumption that diagnostics are accurate enough to successfully interpret the results. Motivated by better understanding of turbulence dynamics, we have used the Controlled Shear Decorrelation Experiment (CSDX) linear plasma device at UCSD which provides a simple system for nonlinear studies of coupled drift-wave turbulence/zonal flow dynamics, and does not have complexities of large toroidal Tokamaks. We present numerical simulations of a minimal model of 3D collisional drift-wave physics in CSDX which evolves density, vorticity and electron temperature perturbations, with proper sheath boundaries conditions. Synthetic diagnostics -virtually measuring plasma quantities of simulation through experimental techniques- such as synthetic Langmuir probes and synthetic camera imaging have been applied to validate the code against experimental measurements, producing a rich basis of comparison. Interestingly, we can observe from the results that some synthetic plasma quantities such as particle flux measured experimentally may differ from real particle flux, while validating experimental measurements. Understanding the missing link between link between computational theoretical models and experimental measurements in magnetically confined devices can immensely increase our interpretation of results. The validation of plasma-turbulence codes plays a fundamental role in the development of magnetically confined fusion, as it is a key step in assessing the maturity of our understanding of the plasma dynamics and the predictive capabilities of simulations, ultimately leading to better and efficient design of future fusion devices.

OPTIMAL POWER MARKET PARTICIPATION STRATEGY OF VARIABLE RENEWABLE ENERGY RESOURCES

Vahid R. Disfani, Ryan Hanna, Jan Kleissl
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In this research, we study a strategy to mitigate the decreasing economic value of variable energy resources (VRE)äóînamely, the coordinated participation of VRE aggregations in the marketplace. We formulate an optimization model and use non-cooperative game theory to study the impact of aggregator operational strategies on wholesale markets. We use this model to determine the optimal bidding strategy for aggregators, considering that all participating VRE sources are operated as an aggregation by one or more aggregators. We find that selling the maximum power generated from VRE generators is not always the most economical strategyäóîwhich is in direct contradiction with current operational strategies for these systems. We also investigate the impacts of the optimal DER participation strategy on the total DER revenue and on the market price.

ONE-YEAR REAL-TIME OPERATIONAL PREDICTION INTERVALS FOR DIRECT NORMAL

Yinghao CHu
UC San Diego

This work describes an algorithm to generate intra-hour prediction intervals (PIs) for the highly-variable direct normal irradiance, which is the energy source for the concentrated solar power technologies. The prediction intervals are generated using a Multi-layer Stochastic-Learning Model (MSLM), which is developed based on methods such as: sky imaging techniques, support vector machine and artificial neural network. The MSLM is trained using one year of co-located, high-quality irradiance and sky image recording in Folsom, California. In addition to being validated with historical data, the algorithm has been generating operational PI forecasts in real-time for that observatory since July 1 st 2014. In the real-time scenario, without re-training or significant maintenance, the hybrid model consistently provides valid PI (PICP ~ 92%) and outperforms the reference persistence model (PICP ~ 85%) regardless of weather condition. This work has great impact in the field of solar energy to potentially facilitate the level of solar penetration in the grid with significantly reduced integration costs.

ZONAL FLOW GENERATION VIS PHASE PATTERNING

Zhibin Guo
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We present a novel mechanism for multi-scale interaction, namely phase pattern formation. The physics of the outer scale of the avalanche distribution remains uncertain. Calculation of the zonal flow pattern structure is necessary to predict it. We show that toroidicity can mediate phase couplings of drift waves at different rational surfaces, so that a global phase dynamics is induced. It is then the roughening of the global phase profile that induces the inhomogeneity of the turbulent Reynolds stress, and hence drives the ZF. The roughness of the global phase profile can drive a ZF from zero, which is different from the conventional modulational instability paradigms where a seed ZF is required. The evolution equation of the global phase is obtained by taking continuous limit of the phase äóÖlatticeäó» in the initial stage. The global phase equation is reduced to an Edwards-Wilkinson equation. The PDF of the spatial spectrum of the phase profile (corresponding to the spatial spectrum of the ZF) is obtained by assuming white noise. In the later stage, the phase-detuning effect of ZF shear is incorporated into the phase evolution equation. Thus, that a new feedback loop, focused on ZF-phase, is uncovered. In the steady state, the phase equation determines the intrinsic spatial structure of the ZF. The “shock layer” solution of the global phase profile corresponds to a strong ZF shear layer with its width determined by the safety factor profile, turbulence intensity, etc. We discuss the relation of phase pattern induced ZF structure to the outer scale of avalanching and thus, ultimately, to the degree of Gyro-Bohm breaking. Both ITG and ETG zonal flows are discussed.