ISSI workshop on electron scales - List of abstracts

Last name	First name	Theme	Title	Abstract
Cozzani	Giulia	1	Electron Firehose Instability in Space Collisionless Plasma	Electron temperature anisotropy-driven instabilities such as the electron firehose instability (EFI) are especially significant in space collisionless plasmas, where collisions are so scarce that wave-particle interactions are the leading mechanisms in the isotropization of the distribution function and energy transfer. Observational studies in different space environments (the solar wind, Earth's magnetotail) provide convincing evidence in favor of the EFI constraining the electron distribution function and limiting the electron temperature anisotropy. Magnetic reconnection is characterized by regions of enhanced temperature anisotropy that could drive instabilities—including the electron firehose instability—affecting the particle dynamics and the energy conversion. However, direct in situ observations of the fluctuations generated by the EFI are elusive and the interplay between magnetic reconnection and EFI is still largely unknown. In a recent study, we use high-resolution in situ measurements by the Magnetospheric Multiscale spacecraft provide the first direct in situ measurement of EFI-generated fluctuations, observed in the magnetic reconnection exhaust in the Earth's magnetotail.
Jiang	Wence	1	Whistler waves and their resonant interactions with electrons in the solar wind and the Earth's magnetosheath: observations and quasi-linear theory	We present in-situ observations of electromagnetic fluctuations of whistler waves and the corresponding electron velocity distribution functions (VDF) from MMS and Solar Orbiter in the Earth's magnetosheath and the solar wind. Using realistic VDFs from these observations, we employ linear Vlasov-Maxwell and quasi-linear theory to illustrate the time evolution of electron VDFs under the resonant action of whistler waves. Consequently, we propose explanations for the origin of whistler waves and their role in energy transfer with electrons.
Klein	Kristopher	1	ALPS: The Arbitrary Linear Plasma Solver	ALPS (Arbitrary Linear Plasma Solver, available at github.com/danielver02/ALPS) is a parallelised numerical code that solves the Vlasov-Maxwell dispersion relation in hot (even relativistic) magnetised plasma. ALPS allows for any number of particle species with arbitrary gyrotropic equilibrium distribution functions supporting waves with any direction of propagation with respect to the background magnetic field. We discuss the basic operations of the Code for application to studying electron instabilities.
Ley	Francisco	1	Secondary Whistler Instability driven by Mirror Modes in Galaxy Clusters	The intracluster medium is a high-beta, weakly collisional, magnetized plasma easily unstable to the pressure anisotropy driven mirror instability, whose presence can affect the macroscopic transport properties of the plasma. We performed high-beta, fully kinetic PIC simulations of the linear, secular and saturated stages of the mirror instability and observed the excitation of secondary whistler and ion-cyclotron instabilities driven by mirror modes, akin to whistler "lion roars" observed in the magnetosheath. The excitation mechanism relates to the trapping process mirror modes provide, and their interaction with electrons and ions is essential to regulate the overall anisotropy. This phenomenon is also observed in lower-beta plasmas, and is argued to be a concomitant feature of the mirror instability.

Li	Yuan	1	Turbulence in the intra-cluster medium	The intra-cluster medium (ICM) is a weakly collisional and weakly magnetized plasma. The electron mean free path in cluster centers is around 10 pc, and in the outskirts of galaxy clusters, it is about 10 kpc, comparable to the size of individual galaxies. Due to the limited spatial and spectral resolutions of X-ray telescopes, it has been rather challenging to observe turbulence in the hot ICM directly. Recently, my group developed a new method to measure ICM turbulence using cool filaments as tracers. These filaments can be observed high-resolution ground-based optical and radio telescopes. They are ubiquitous in cluster centers and can also be found in cluster outskirts in the tails of jellyfish galaxies. We study the kinematics of the filaments by measuring their velocity structure function (VSF) over a wide range of scales in both cluster centers and outskirts. The cluster center filaments show peculiar VSFs that are much steeper than classical Kolmogorov expectations and the reason is still under debate. In the tail of a jellyfish galaxy in cluster outskirts, the motions of the filaments appear to follow turbulence driven by Kelvin-Helmholtz instability. The detection of turbulence under the mean free path puts unprecedented constraints on the effective isotropic viscosity of the ICM.
Pezzi	Oreste	1	Insights on electron-scale turbulence by means of Eulerian Vlasov-Maxwell simulations	I will show recent results concerning electron-scale plasma turbulence obtained employing the recently-developed Eulerian Vlasov-Maxwell algorithm ViDA. The typical plasma parameters have been selected to be close to the near-Earth conditions in the magnetosheath. The emergence of electrostatic turbulence, mediated by fluctuations compatible with Bernstein modes, will be discussed in detail.
Stawarz	Julia	1	Electron-Only Reconnection in Turbulent Plasma	I will discuss recent observations of turbulence-driven reconnection made by NASA's Magnetospheric Multiscale mission, which have revealed a novel type of magnetic reconnection that has come to be known as electron-only reconnection. Electron-only reconnection has been found to occur at thin electron-scale current sheets and, unlike traditional reconnection, is not associated with the acceleration of ion outflows. The origin and implications of this novel type of magnetic reconnection in the context of turbulent plasmas will be discussed.
Svenningsson	Ida	1	Electron velocity-space scattering from whistler waves in the Earth’s magnetosheath	We use MMS measurements to study the occurrence and properties of whistler waves in the Earth’s magnetosheath. The whistlers are not correlated with high electron temperature anisotropy, indicating that non-Maxwellian electron distributions play a role in the wave generation. By calculating pitch-angle diffusion coefficients, we find that whistler waves can significantly reshape the velocity distribution of electrons passing through the magnetosheath.
Aizawa	Sae	2	Electron acceleration in the magnetosphere of Mercury	Due to the smaller scale of Mercury's magnetosphere compared to that of Earth, electron are expected to get accelerated more effectively and its kinetics is expected to be more important. Recent results by simulations and BepiColombo observation, and forthcoming observation will be discussed.
Amano	Takanobu	2	Stochastic shock drift acceleration as a mechanism of electron injection at collisionless shocks	Stochastic shock drift acceleration (SSDA) has been emerging as a promising mechanism of electron injection into the standard diffusive shock acceleration at high-Mach number quasi-perpendicular shocks. We discuss the current status and future perspectives of SSDA.

Artemyev	Anton	2	Relativistic electrons in Earth's magnetotail: compact & effective acceleration	Earth’s magnetotail region hosts the magnetic reconnection, the primary site for charged particle acceleration. The spatial localization and transient nature of the magnetotail reconnection suggest quite moderate efficiency of the electron acceleration that should not exceed sub-relativistic energies. This presentation shows quite atypical examples of much more effective acceleration in such compact space plasma system, where electrons reach multi-MeV energies.
Coburn	Jesse	2	Velocity space methods for kinetic plasma processes	In the kinetic equation, the electromagnetic and collisional operators are both mediated by the velocity space gradient of the distribution function. We implements a Hermite expansion to obtain noise-less and trustworthy velocity distribution functions, and their gradients. I will show recently published results on solar wind whistler-electron interactions and preliminary results on measuring the full Landau collision operator.
Cozzani	Giulia	2	Electron physics of magnetic reconnection: the patchy Electron Diffusion Region (EDR) and the interaction with lower hybrid drift waves	The electron diffusion region (EDR) is a key magnetic reconnection region where both electrons and ions are demagnetized and reconnection is enabled. EDRs have been observed to be ''laminar'' (i.e. homogeneous region where the reconnection is controlled by a steady out-of-plane electric field) or ''patchy'' (with electron-scale large-amplitude positive and negative peaks of J.E’). The origin of the ‘’patchiness’’ is not fully understood but a recent study suggests that its predominant source is the time variability of the inflowing magnetic field direction. The EDR patchiness could influence electron heating and acceleration during reconnection, but this topic is largely unexplored. The EDR can be perturbed by the presence of waves at the lower hybrid scales. Depending on the guide field strength, electrostatic or electromagnetic lower hybrid waves (LHDW) can be present at the current sheet center. Electrostatic waves are associated with electron heating and vortical flows in the EDR in the Earth’s magnetotail with moderate guide field. Electromagnetic mode (with longer wavelength) are found to perturb the magnetotail EDR in case of low guide field and lead to current sheet kinking.
Grassi	Anna	2	Exploring the physics of turbulent collisionless shocks in conditions of laboratory experiments	Collisionless shocks are ubiquitous in astrophysical plasmas and play an important role in magnetic field generation/amplification and particle acceleration. While diffusive shock acceleration (DSA) is well established, the details of particle injection into DSA remain a long-standing puzzle, particularly for electrons. High-energy-density (HED) plasma experiments and kinetic plasma simulations offer a promising route to identify the dominant processes at play. Very recently experiments performed at the National Ignition Facility have observed for the first time the formation of high-Mach number collisionless shocks mediated by electromagnetic instabilities and nonthermal electron acceleration. I will discuss the physics behind shock formation and particle acceleration in these laboratory systems and how they can be connected to astrophysical models. Using large-scale, multi-dimensional particle-in-cell (PIC) simulations, we find that the inhomogeneous profiles of laser-ablated plasmas lead to shock formation that can be up to 10 times faster than previous models predicted. Finally, we show that electrons can be effectively accelerated to nonthermal energies and injected into DSA via a Fermi-like mechanism occurring within the finite, turbulent shock transition. These findings can help guide the development and interpretation of current experimental programs and open exciting prospects for studying the microphysics of turbulent collisionless shocks in the laboratory.

Grigorenko	Elena	2	Intense Electron-scale Current Structures and associated Energy Conversion Observed in the magnetospheric Plasma Sheet during Propagation of High-Velocity Bulk Flows	High-resolution MMS observations found that reconnection outflows have a lot of intense Electron-scale Current Structures (ECSs) distributed over the entire Plasma Sheet region. The ECSs are the sites of strong nonideal electric fields generation and associated energy conversion with J·E' up to several nW/m3, which is comparable with J·E' reported for Electron Diffusion Region of the magnetotail reconnection. The dissipating energy can be transferred to electron heating and acceleration.
Jeffrey	Natasha	2	New methods for diagnosing the properties of flare-accelerated electrons at the Sun and in the heliosphere	Solar flares are efficient electron accelerators, producing different populations of energised electrons in the 10s–100s keV range that we can observe at the Sun via remote sensing observations and at different locations in the heliosphere with in-situ observations. In this talk, I will summarise new methods for constraining the properties of electron acceleration in flares (mechanism, location), including using stereoscopic X-ray observations with SolO/STIX and Earth-orbiting missions and detecting signatures of hot, over-dense plasma in the spectra of electron in-situ data to pinpoint acceleration locations.
Khotyaintsev	Yuri	2	Electron heating by parallel electric fields and electrostatic waves in reconnection and shocks	Magnetic reconnection creates a driven physical system in which the magnetic energy is dissipated and converted to other forms of energy. In collisionless plasmas, this generates strongly non-equilibrium electron distributions with sharp gradients in both real and phase space. The non-equilibrium distributions drive various plasma waves, which have been frequently observed in situ by spacecraft in the Earth's magnetosphere. These include intermediate-frequency lower hybrid and whistler-mode waves, electrostatic broadband and solitary waves, and the high-frequency upper hybrid, Langmuir, and electron Bernstein waves.
Martinović	Mihailo	2	High Cadence Electron Parameters Measured by Wind Spacecraft using Quasi-Thermal Noise Spectroscopy	Quasi-thermal noise (QTN) spectroscopy is an accurate tool to measure electron density and temperature in space plasmas. We present a new method for selecting the observations of uncontaminated QTN, distinguishing it from other plasma and spacecraft effects and demonstrate the application of the method to obtain high cadence electron moment measurements in the vicinity of Earth's bow shock.
Musset	Sophie	2	Particle acceleration during solar flares: observational diagnostics	In the corona, energetic electrons emit both bremsstrahlung emission in X-ray and gyrosynchrotron emission in radio: these diagnostics can be combined together and with diagnostics of the magnetic field and active region configuration to determine the sites of particle acceleration and the possible acceleration mechanisms at play. I will review recent results on the acceleration site locations and acceleration mechanisms during solar flares and discuss the conditions in which these accelerated particles can access the interplanetary medium and fill the heliosphere.
Nakamura	Rumi	2	Electron acceleration directly by the reconnection electric field and macroscopic acceleration in the Earth's magnetotail	In this talk I would like to present the electron observations from direct acceleration along the reconnection electric field in the Earth's magnetotail as well as examples of the subsequent acceleration in the outflow region including its characteristics. Furthermore, overall limitation of observing such acceleration in the Earth's magnetotail system is discussed.

Nichols	Jonathan	2	Magnetosphere-ionosphere coupling at the outer planets, brown dwarfs and exoplanets	Planetary magnetospheres are natural laboratories for the study of space plasmas, and in particular how charged particles are accelerated to high energies. The magnetospheres of the outer planets in particular provide a link with more distant astrophysical bodies, which we cannot measure in situ. The coupling between the ionosphere and magnetospheres of planetary bodies (and, as we conjecture, similar objects beyond the solar system) produces powerful auroral emission that can be used as a tool to understand the energetic processes occuring in the magnetosphere. In this talk we discuss the current ideas regarding magnetosphere-ionosphere coupling at Jupiter, and how these ideas have been extended to discuss similar processes at brown dwarfs and exoplanets.
Niemiec	Jacek	2	Electron injection at cluster shocks	I will review our recent work on electron pre-acceleration in low Mach number nonrelativistic shocks in hot intracluster medium. I will discuss turbulent shock structure and show that electron injection to DSA can be provided through stochastic shock-drift acceleration process.
Oka	Mitsuo	2	Electron acceleration in solar flares and Earth's magnetotail	In both fields of Solar Physics and Magnetospheric Physics, it remains unclear how energies are partitioned between thermal and non-thermal components. I would like to present a brief overview of recent observational results and expectations for future observations and simulations.
Riquelme	Mario	2	Electron Acceleration by Temperature Anisotropy Instabilities in Solar Flares	Using 2D particle-in-cell plasma simulations, we study electron acceleration by temperature anisotropy instabilities, assuming conditions typical of above-the-loop-top sources in solar flares. We focus on the long-term effect of T_e,perp > T_e,parallel instabilities by driving the anisotropy growth during the entire simulation time through imposing a shearing or a compressing large-scale (and slow) plasma velocity. Significant non-thermal tails are found, which we will discuss in the talk.
Sahraoui	Fouad	2	On the different ion vs. electron heating in astroplasmas	Some of the key questions in astroplasmas are: i) what sets the amount of energy dissipated into ion and electron heating as turbulent cascade proceeds from large to small scales ? And which scales dissipation is most effective? I'll discuss recent theoretical and observational (MMS) progress achieved on these problems.
Schwartz	Steve	2	Energy partition at collisionless shocks	I will review what is known, and not known, about how the incident energy at a collisionless shock is partitioned amongst the different species and fields. I will also touch on the heating mechanisms believed to be responsible for the electron component of that partition. State-of-the-art data is able to provide rich detailed information on these processes.
Shuster	Jason	2	Electrons Can Smile (even though they’re negative!): MMS Observations and PIC Simulations of Electron Gradient Distributions in the EDR of Asymmetric Reconnection	The unprecedented temporal, spatial, and velocity-space resolution offered by the MMS tetrahedron enable us to obtain direct observations of each term in the electron Vlasov equation, which governs the evolution of plasmas in six-dimensional phase space. The terms of the Vlasov equation are determined from electron phase-space density gradients measured by MMS in the vicinity of asymmetric magnetic reconnection occurring at Earth’s magnetopause. In both MMS data and particle-in-cell (PIC) simulations, a highly-structured, ‘smile’-shaped electron spatial gradient distribution is discovered that corresponds to demagnetized electron crescent distributions specific to the central electron diffusion region (EDR) of asymmetric reconnection, which is critical to our understanding of how spatial variations in the electron ensemble self-consistently support the reconnection electric field via net contributions to the bulk electron pressure divergence.
Wilson	Lynn	2	Electron velocity distribution functions in the solar wind	We discuss observations of electron velocity distribution functions (VDFs) in the solar wind observed by the Wind spacecraft near 1 AU. Emphasis will be placed on deviations from isotropic Maxwellian VDFs and the importance of the kinetic features in each subcomponent of the distributions.

Zenitani	Seiji	2	Some topics on a relativistic Kappa distribution	I will present a Monte-Carlo procedure for generating a relativistic Kappa distribution in particle-in-cell (PIC) simulation. Then I will evaluate nonthermal fractions of the distribution, extending Oka (2013)'s method to the relativistic regime. I will also compare several definitions of nonthermal fractions.
Kunz	Matthew	3	Microscale-mediated transport in weakly collisional astrophysical plasmas	Departures from local thermodynamic equilibrium in weakly collisional plasmas drive microscale kinetic instabilities if the plasma beta is sufficiently large. These rapidly growing instabilities (e.g., firehose, mirror, whistler) interact with particles in such a way as to regulate the transport of momentum and heat and impact the electrical resistivity of the plasma. I will provide an update on our efforts to understand not only how this regulation occurs in detail (e.g., effective collision operators), but also its macroscale consequences for turbulence, dynamo, heating, and cosmic-ray transport.
Micera	Alfredo	3	Heat flux regulation by collisionless processes in the solar wind	By employing Particle-in-Cell (PIC) simulations, we study electron VDFs that reproduce those typically observed in the inner heliosphere and investigate whether the strahl electrons and the electron deficit may contribute to the onset of kinetic instabilities and to heat flux regulation in the solar wind. We observe that the strahl electrons drive oblique whistler waves unstable which scatter them in turn. As a consequence of these scattering processes, the suprathemral electrons can occupy regions of phase space where they fulfill resonance conditions with the parallel-propagating fast-magnetosonic/whistler wave. The suprathermal electrons lose kinetic energy, resulting in the generation of unstable waves. The sunward deficit, initially depleted of electrons, is thus gradually filled by electrons that are resonant with the triggered whistler waves. As this initial deviation from thermodynamic equilibrium is reduced, a decrease in the electron heat flux occurs.
Owen	Christopher	3	Observations of Strahl Beams and Deficits in the solar wind suprathermal electron populations with Solar Orbiter EAS	We summarise some of our recent work using Solar Orbiter SWA/EAS measurements to examine the nature and variations of the 'strahl' populations and the 'deficits' in the sunward directed parts of the electron velocity distribution functions in the solar wind.
Simionescu	Aurora	3	Remote sensing plasma physics diagnostics from high-resolution X-ray spectra	I will discuss how observers can gain information about various plasma processes in (very) remote astrophysical objects, with a focus on the diffuse intracluster medium. How do we identify shocks, measure turbulence, estimate electron-ion temperature equilibration, how do we trace the effects of conduction or a kappa-distribution, when we cannot get in-situ measurements? I will in particular discuss the opportunities and challenges in light of newly launched and upcoming X-ray telescopes offering high spectral resolution imaging information.
Stverak	Stepan	3	Role of Coulomb collisions for heat transport in solar wind plasma	Is the solar wind heat flux collisional or collisionless? A brief discussion on how the radial gradients of electron temperature and heat flux are linked together and if and how they are driven by Coulomb collisions.
Verscharen	Daniel	3	Creation and regulation of heat flux in the solar-wind electron distribution	The non-thermal features of the electron distribution are the result of a complex interplay between global expansion effects, collisions, and local interactions between the particles and the electromagnetic fields. I will discuss the formation of the relevant features in the electron distribution and analyse their impact on the linear stability of whistler waves in the inner heliosphere. Results from our ALPS code show that the strahl-core-deficit configuration near the Sun drives oblique whistler waves unstable. As the distribution evolves, the sunward deficit fills with electrons, at which point the plasma becomes unstable and drives parallel whistler waves.