

#	Scientific questions	Explanatory Sentences	Opportunities	Opp. in topics
1	How do magnetic explosions work?	Magnetic reconnection drives exploding events such as solar and stellar flares, substorms in planetary magnetospheres and disruptions in laboratory fusion experiments. Why is the magnetic energy released as an explosion and why is the conversion of this energy to energetic particles so efficient?	Ongoing and future satellite missions, large-scale 3D computations, and the next generation of laboratory experiments on magnetic reconnection with large effective sizes and low collisionality	1.1, 1.3, 4.1
2	How are cosmic rays accelerated to ultrahigh energies?	Energetic particles bombarding the Earth from space have energies up to 10 ¹⁹ - 10 ²⁰ eV with a power-law distribution with a spectral index of about 2.8. What is the source of these cosmic rays? In analogy with the energetic particle enhancements observed at virtually all heliospheric shocks, supernova shocks are invoked as the source of particles up to 10 ¹⁵ eV. However, the source of the higher energy cosmic rays remains unknown.	Combinations of new remote-sensing observations, in-situ heliospheric measurements, large-scale computing, laboratory experiments on collisionless shocks (including relativistic beam dissipation), plasma turbulence studies, and magnetic reconnection studies.	2.1, 2.2, 2.3, 3.1, 9.1
3	What is the origin of coronae and winds in virtually all stars, including Sun?	Most stars have hot coronae, with temperatures exceeding a million degree. The Sun not only has a hot corona, but also a hot wind stretching to the interstellar medium. How are these nearly collisionless plasmas heated by waves, turbulence and reconnection? What is the nature of anisotropic MHD and collisionless turbulence? What role do these processes play in accretion disks, interstellar medium, and inter-cluster medium?	Ongoing and future satellite missions in the heliosphere, present and planned ground and space-based telescopes for astronomical observations, laboratory experiments in the weakly collisional and collisionless plasma regimes, and computational studies in MHD, Hall MHD, and fully kinetic/gyrokinetic models.	3.2, 4.2, 5.3, 6.1, 6.3, 9.1, 9.2, 10.1, 10.3
4	How are magnetic fields generated in stars, galaxies, and clusters?	Our sun, and stars of many different types, show evidence for strong, coherent magnetic fields, sometimes cyclic. Galaxies, and perhaps accretion disks, also have coherent magnetic fields. Magnetic fields are present in galaxy clusters as well. Understanding the origin of these fields and being able to predict their properties in terms of the underlying system is key to understanding the evolution of stars and galaxies, and the nature of accretion.	A synergistic combination of observations, experiments, and simulations, each operating in a variety of different parameters, may lead to a unified understanding of what determines the origin and evolution of stellar, interstellar, and intergalactic magnetic fields.	4.1, 6.2
5	What powers the most luminous sources in the universe?	Accreting supermassive black holes generate prodigious fluxes of radiation, so intense that radiation pressure can dominate gravity. This condition should disrupt the accretion in ways not understood. Understanding this super-Eddington accretion is central to understanding the most luminous sources that light up the universe.	Rapid accretion models due to effects by magnetic fields and radiation models in the inner most part of the accretion disks will be subject for serious laboratory tests, which may lead to predictions based on first principles	5.2, 6.1, 6.3, 8.3

6	How is star and planet formation impacted by plasma dynamics?	Interpreting observations of star and planet formation requires advances in radiative transfer theory, chemistry in a turbulent fluid with charged dust, and magnetized turbulence. At the same time, two old problems in star formation theory - the magnetic flux problem and the angular momentum problem - have not yet been solved.	Significant opportunities exist for laboratory studies of dynamics of dust grains, rapid accretion in partially ionized plasmas, and radiation transfer. These will advance our understanding of theory and observations of star and planet formation.	6.1, 7.1, 7.2, 7.3, 8.1, 8.4
7	How do magnetic field, radiation and turbulence impact supernova explosions?	Supernovae represent nature's grandest explosion. These explosions are singularly non-spherical. How gravity, magnetic fields, turbulence, neutrino transport, and radiation all work in concert to generate these extraordinary explosions remains one of nature's most enduring puzzles.	Improved understanding via new algorithms, exaflop computing, or experiments on neutrino transport, radiative heat transport, turbulent mixing, and radiative shock during supernova	5.6, 8.2
8	How are jets launched and collimated?	Powerful jets are observed in a variety of systems, ranging from protostars to supermassive black holes. Magnetic fields are believed to govern the physical processes in jet formation but we do not know how. Why are jets stable across decades of scales? It is also imperative to understand how jets significantly affect the surrounding medium by depositing a major fraction of the total energy over large spans of scales.	Interdisciplinary opportunities exist in studying launching, collimation, and stability based on combinations of observations, experiments and simulations.	5.4, 9.3, 10.1, 10.2, 10.3
9	How is the plasma state altered by ultra-strong magnetic field?	When magnetic energy density is higher than the rest mass energy density of plasmas, the plasma dynamics (propagation and dissipation) is altered, as found in environments such as pulsars and relativistic jets. Electron and positron pairs are often produced in such regimes. How to convert magnetic energy to plasmas is not known.	New laboratory opportunities emerge in this area, supported by numerical and theoretical research as well as observations	1.2, 5.5, 9.2, 9.4
10	Can magnetic fields affect cosmological structure formation?	Depending on when and how they originated, magnetic fields could have played an important role in the formation and evolution of cosmic structures through their effects on the dynamics and energy balance of the baryonic component.	Ongoing and future observations of magnetic fields in the intra-cluster medium and understanding their impact on the physics of clusters. Search for magnetic fields at moderate redshift, and at high redshift, through their imprint on the Cosmic Microwave Background.	None