<table>
<tr><td>*</td><td>Area</td><td>Solar Physics (USO)</td></tr>
<tr><td></td><td colspan="2">Udaipur Solar Observatory, as the name suggests is a dedicated facility to study the sun, the nearest star. Investigations of the Sun at USO revolve around the central theme of solar magnetic and velocity fields, solar activity, solar eruptive processes and high resolution solar observations. Efforts are being made to get a handle on the forecasting of these violent solar events. Basic physical phenomena of the birth and development of active regions, and flare mechanism can also be studied. The major experimental facilities include the Global Oscillation Network Group (GONG), the Multi Application Solar Telescope (MAST) and the Compound Astronomical Low frequency Low cost Instrument for Spectroscopy and Transportable Observatory (CALLISTO).</td></tr>
<tr><td>1</td><td>Sub-Area</td><td>Helioseismology (USO)</td></tr>
<tr><td></td><td colspan="2">Helioseismology is based on precise measurements of solar acoustic oscillations. The study of the solar global oscillations during major flares have shown that such energetic transients taking place in the solar environment can generate pressure impulses in the Sun. The knowledge gleaned from these solar results can be useful in identifying the asteroseismic signatures of such transients in solar-like pulsating stars. The study of these acoustic oscillations in the sunspots during major flares have shown that abrupt changes in solar magnetic fields can lead to impulsive changes in Lorentz force acting on the sunspots, which results into inducing acoustic emission in the sunspots. These acoustic emissions could be helpful in better understanding of physical dynamics beneath the sunspots. Additionally, such magnetically driven acoustic emissions can travel upward into the solar atmosphere as magnetoacoustic waves and thereby heat the active region atmospheres. It is also believed that acoustic waves can leak from the quiet-Sun network regions of the solar photosphere and travel upward into the chromosphere there by dissipating its energy in the form of shocks. A two-height simultaneous velocity observations in the solar photosphere and chromosphere at high resolution is required for a better understanding of the aforementioned wave heating process. Further, the study of velocity flows on the solar surface over the solar cycle can give an understanding of the effect of the evolution of solar magnetic fields on the dynamics of the Sun.</td></tr>
<tr><td>2</td><td>Sub-Area</td><td>Flux emergence and the coupling of the solar atmosphere (USO)</td></tr>
<tr><td></td><td colspan="2">The emergence of magnetic fields on the solar photosphere occurs on a wide range of spatial and temporal scales. Investigating the processes of flux emergence is essential for understanding how the magnetic field couples the solar atmosphere and in determining
i) the heating of the transition region and corona,
ii) the production of small-scale transients, and
iii) the instabilities driving mass ejections from the Sun.
This field of solar physics requires multi-wavelength and multi-resolution observations which will provide an unprecedented view of the Sun and its magnetic field with the next-generation ground-based telescopes and space missions becoming operational within 2-3 years.</td></tr>
<tr><td>3</td><td>Sub-Area</td><td>Magnetic field and velocity mapping for prediction of solar eruptions (USO)</td></tr>
<tr><td></td><td colspan="2">Solar surface magnetic field is measured to monitor magnetic energy storage and evolution of the stresses leading up to these eruptions combined with the velocity measurements on the surface. Above the surface, physical parameters of the chromospheric and coronal phenomena are being used to predict the geoeffectiveness of these eruptions.</td></tr>
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4	**Sub-Area**	**Solar cycle variation, prediction of activity cycle (USO)**
	The 11-year activity cycle is a dominant characteristic of the Sun and also the solar dynamo that generates the solar magnetic field. The discovery of solar magnetic fields introduced a 22-year periodicity, as the magnetic polarities of the polar regions change sign every 11 years. Correlations have been identified and quantified among all the measured parameters, but in most cases such correlations remain empirical rather than grounded in physical processes. For a better physical understanding of solar physics a systematic reassessment of solar activity indices and their usefulness in describing and predicting the solar activity cycle is required.	
5	**Sub-Area**	**Study of solar rotation (USO)**
	The differential rotation of the Sun plays a key role in the formation of sunspots and thereby governs the solar activity cycle. Recently it is shown that the solar corona also shows differential rotation with increasing height (or, temperature). Furthermore, the study of North-South asymmetry in the rotation of the Sun has indicated that this asymmetry leads the solar activity cycle. The study of chromospheric rotation with height and its variation over the solar activity cycle can improve our understanding about the differential nature of the solar rotation.	
6	**Sub-Area**	**The heating of solar corona and transition region (USO)**
	The tenuous outer atmosphere of the Sun commonly known as 'corona', is orders of magnitude hotter (> 1 MK) than the solar surface (< 6000 K). It is now widely accepted that magnetic field plays an important role in the heating of solar corona. Magnetohydrodynamic (MHD) waves and small-scale transients (e.g., microflare, nano-flare, spicules) are proposed to provide sufficient energy to maintain the hot corona and transition region. Although there exist ample observations of wave propagation and small-scale transients in the solar atmosphere, the exact physical processes/mechanisms behind their dissipation and contribution to the heating of coronal plasmas are still unclear and not fully quantified. Therefore, a thorough assessment of the role of each of these proposed mechanisms is required.	
7	**Sub-Area**	**Transient Phenomena: Flares, Eruptive Filaments/Prominences, Coronal Mass Ejections (USO)**
	CMEs inject large amounts of mass and magnetic fields into the heliosphere, causing major geomagnetic storms and interplanetary shocks, which are a key source of solar energetic particles. CMEs are often associated with erupting prominences and flares but our physical understanding of how and why CMEs are initiated is poor. It is important to carry out long term and high resolution studies of source regions of CMEs and also monitor their manifestations in the solar wind. Further, study of halo-like CMEs, which suggest the launch of a geoeffective disturbance toward Earth is also very important for space weather forecasting purpose. The fast and wide CMEs produce coronal and interplanetary shocks which are observed as type II radio bursts in meter and Decameter-hectometer (DH) wavelengths. The investigation of solar radio bursts in metric and DH wavelengths is also extremely important in view of probing the origin and propagation of CMEs.	
8	**Sub-Area**	**Multi-wavelength studies of the Sun (USO)**
	Our understanding of the solar interior, the visible outer layers, and the "invisible" corona are not complete. New developments in the observational techniques from ground and space in optical, X-ray, ultra-violet and radio regimes of the electromagnetic spectrum are expected to continuously extend the frontiers of knowledge of the Sun in	

	particular the eruptive phenomena such as flares and CMEs. Further, the HXR spectroscopy of solar flares is of particular importance to explore the basic physics of particle acceleration and explosive energy release in solar flares. Combination of imaging and spectroscopic observations in X-ray regime would reveal the location and strength of accelerated electrons and ions besides that of the hottest plasma.	
9	**Sub-Area**	**Numerical simulation for solar atmosphere (USO)**
	The solar corona is intriguing because of its million degree Kelvin temperature and hosting eruptive processes which releases energy and mass which influence the space weather. In absence of any reliable measurement of the coronal magnetic field, it becomes important to numerically construct it using photospheric observations from ground and space based observatories. Additionally, state-of-the-art computer simulations are employed to explore the coronal dynamics.	
10	**Sub-Area**	**Heliospheric evolution of CMEs and their space weather impact (USO)**
	When coronal mass ejections or CMEs are launched from the Sun, they arrive at Earth within 1-4 days depending upon their initial speeds and their level of interaction with the ambient solar wind through which they travel. Research is being carried out for a better understanding of the expansion and propagation of CMEs in the inner heliosphere, thereby improving the forecasting of CME arrival and their impact on the Earth's atmosphere. Such knowledge is crucial, as energetic and high speed CMEs are known to be the major cause of severe disturbances of the Earth's space weather.	
11	**Sub-Area**	**Instrumentation (USO)**
11.1	**Optical instrumentation for Solar observations (USO)**	
	A 50 cm telescope for solar observations. Specialised back-end instruments, namely a Narrow–band Imager to record simultaneous images of the photosphere and chromosphere, a Polarimeter to measure the magnetic fields in sunspots and an Adaptive Optics system for image stabilisation and to achieve diffraction-limited performance.	
11.2	**Active and adaptive optics for diffraction limited imaging (USO)**	
	To achieve high-resolution observations with ground-based telescopes, Udaipur solar observatory (USO) is engaged in the research and development of active and adaptive optics systems for compensation of atmospheric turbulence in real-time. A low-order adaptive optics system is already developed; to achieve the maximum possible resolution with existing telescopes at USO, the development of a high-order AO system is in progress. In this regard, different mechanisms/techniques are being explored for wavefront sensing and wavefront reconstruction. Besides, off-line image restoration techniques such as blind-deconvolution and speckle masking techniques are being explored.	