Science

Science Goals

Click here for instructions on how to join the WEAVE Science Team and guidelines for existing Science Team members.

WEAVE (WHT Enhanced Area Velocity Explorer) is the next-generation wide-field survey facility for the William Herschel Telescope (WHT). Expected to start operations in early 2023, its goals are to complement the major space- and ground-based programmes in the current and coming decade, including Gaia, LOFAR and Apertif, by providing a dedicated wide-field optical spectroscopic instrument in the Northern Hemisphere.

Its wide-ranging science goals cover various fields of Galactic and extragalactic astronomy. There are currently eight independent WEAVE surveys planned, each with their own dedicated Science Teams, that will use a large fraction of 5 years of WHT time. WEAVE, with its nearly 1000-fibre MOS mode and IFU modes, will also be accessible to the wider astronomical community through open competition outside of this time.

A short overview of each of the planned WEAVE surveys is provided below, starting from surveys focusing on the nearby Universe and extending towards higher redshifts.

Click here for a photo gallery of the Science Team Leads.

The WEAVE Science Case is available to the public here: WEAVE-SCI-002 The WEAVE Science Case v3.2.pdf

Galactic Archaeology (GA) (Team Lead: Vanessa Hill)

The Milky Way (MW) is the only galaxy for which we can determine a precise chemo-dynamical formation and evolutionary history. The Gaia satellite is revolutionising the study of the MW and its satellite companions by delivering photometry, 3-D positions, and proper motions for 1.8 billion stars brighter than G = 20.8.

Fully exploiting the Gaia data requires obtaining accurate radial velocities and elemental abundances for stars that are too faint for Gaia's Radial Velocity Spectrometer (RVS). For stars with V magnitude fainter than 15-16 (radial velocities) or V fainter than 12 (elemental abundances), WEAVE's Galactic Archaeology survey will provide exactly such data, enabling the determination of fundamental Galactic parameters (mass, mass assembly over time, etc.), the origin of the thick stellar disk, identifying/characterising streams of stars in the Galaxy's halo to understand the fraction of the halo originating in accreted systems, and performing fundamental galaxy-dynamics experiments to understand the rôle of non-axisymmetries in disk substructures.

WEAVE's vantage point from the Northern Hemisphere is crucial for targeting the outer MW disk. The WEAVE Galactic Archaeology survey will be unique; no other existing or proposed optical facility (e.g. LAMOST, DESI, SDSS) will provide such a survey to similar depth or spectral resolution, while the southern sky inaccessible to WEAVE will be covered by ESO's forthcoming 4MOST facility. The Galactic Archaeology survey is divided into sub-surveys targeting the Galactic halo, disk(s) and open clusters, using both the low and high-resolution modes of WEAVE (R~5000 and R~20000, respectively), targeting millions of stars.

Read more about the GA survey

Stellar, Circumstellar and Interstellar Physics (SCIP) (Team Lead: Janet Drew)

The Milky Way's disk is an outstanding location for studying the physics of the many, poorly understood, short-lived phases of stellar evolution, from the most massive O stars, through Cepheids, to stellar remnants and their ejecta. The SCIP survey will target these stars along with their environment (i.e. the circumstellar and interstellar medium) over more than 1200 sq. deg. of the Galactic disk; this will allow WEAVE to address questions regarding the relations between star formation, evolution, and the ISM seen both in emission and absorption. For the youngest OBA stars, the SCIP survey will complete the kinematics of stars with Gaia astrometry. A high-spectral-resolution focus on the Great Cygnus Rift star-forming region and the Galactic Anticentre will enable targeted studies of, respectively, high-mass stars within an important complex, and of Galactic structure and dynamics in the Anticentre region.

Read more about the SCIP survey

Galaxy Clusters (Team Lead: J. Alfonso Lopez Aguerri)

The Galaxy Clusters survey will focus on three different science areas. A survey of low-mass cluster galaxies will trace the evolution of bright dwarf galaxies in X-ray-selected nearby galaxy clusters up to a redshift of 0.04. In the infall-regime survey, the focus will be on characterising the transformation of galaxies during their infall process towards the cluster centre. For this purpose, a total of 20 galaxy clusters with a range of masses at z~0.05 will be targeted. Lastly, the cosmological clusters survey will study the evolution of galaxies in cores of clusters out to a redshift of 0.5, also placing constraints on cosmological parameters and global scaling relations using a complete sample of Sunyaev-Zeldovich clusters.

Rad more about the Galaxy Clusters survey

Stellar Populations at intermediate redshifts Survey (StePS) (Team Lead: Angela Iovino, Deputy Lead: Amata Mercurio)

The StePS survey (Iovino et al., 2022, A&A, submitted) will obtain high-quality spectra (typical S/N 10Å^{1} at R 5000) for a magnitude-limited (I_{AB} < 20.5) sample of 25,000 galaxies, the majority in the redshift range between 0.3 and 0.7. The survey goal is to provide precise spectral measurements in the crucial interval that bridges the gap between LEGA-C and SDSS data.   StePS will use WEAVE to trace back in cosmic time the evolution of galaxy stellar population properties as a function of galaxy stellar mass, star formation activity and environment, thereby providing much needed empirical constraints on the physical mechanisms that regulate galaxy formation and assembly history.

Read more about the StePS survey

WEAVE-Apertif (Team Lead: Jesús Falcón-Barroso)

Apertif is an innovative focal-plane array system on the Westerbork synthesis radio telescope in Dwingeloo that will allow wide-field HI surveys out to cosmological distances (z~0.2). With commissioning expected to finish in early 2017, Apertif will provide radio-source targets to WEAVE for optical follow-up of 100,000 massive gas-rich galaxies in a timely fashion. The WEAVE-Apertif survey will be able to harness WEAVE's dual integral-field-unit (IFU) capability, as the large IFU will be ideally suited for large nearby galaxies, while the multiple small IFUs will be perfect for small and distant galaxies.

Read more about the WEAVE-Apertif survey

WEAVE-LOFAR (Team Lead: Dan Smith)

The Low Frequency Array (LOFAR) is a new-generation radio telescope, with unparalleled sensitivity and survey speed due to its very large instantaneous field of view, a result of its innovative design. The LOFAR Surveys Key Science Project is producing tiered surveys across the entire northern sky, providing precise positions for WEAVE, which will be its primary source of redshift information. The WEAVE-LOFAR survey will perform multi-object and resolved optical spectroscopic follow-up of more than a million low-frequency selected radio sources, enabling a very wide and exciting range of science questions to be addressed. Topics range from measuring the evolving relationship between star formation and accretion — including accounting for the influence of mass and environment — to identifying radio galaxies deep in the epoch of reionisation.

Read more about the WEAVE-LOFAR survey

WEAVE-QSO (Team Lead: Mat Pieri)

How did the accelerated expansion of the universe emerge? How do galaxies regulate gas accretion and hence star formation? How is this star formation connected to (circumgalactic) environment and the (intergalactic) cosmic web context? How do the sources of (re)ionisation imprint themselves onto the intergalactic medium? These are some of the pressing questions motivating the extragalactic astrophysics planned within the WEAVE-QSOs survey. The primary target of observations will be the Lyman-alpha forest — a 'forest' of absorption lines seen along the line of sight to distant QSOs that are caused by the intervening intergalactic medium (IGM) and circumgalactic medium (CGM). The WEAVE-QSOs survey will provide IGM/CGM temperature, density, 3-D mapping and clustering. Clustering information includes the measurement of Baryonic Acoustic Oscillations, a 'standard ruler' enabling us to probe the accelerating expansion of the Universe and thus gain a better understanding of 'dark energy'.

Read more about the WEAVE-QSO survey

WEAVE-WD (Team Lead: Boris Gaensicke)

What is the star formation history in the solar neighbourhood? How much mass do stars lose when they evolve off the main sequence? What are the progenitors of type Ia supernovae routinely used to map the Universe? And what happens to the many known planetary systems (including our solar system) once their host stars reach the end of hydrogen-core burning? These fundamental questions are all addressed by the study of white dwarfs, the endpoints of stellar evolution for ~95% of all stars. WEAVE-WD will obtain high-quality spectra of ~60,000 white dwarfs identified by the ESA Gaia mission, and the analysis of these data will provide accurate masses and ages from which the local star formation history, the initial mass function, and the initial-to-final mass function will be determined. WEAVE-WD will be the largest sample of spectroscopically confirmed white dwarfs, and provid e detailed statistics on the frequency of double-degenerate white dwarfs that will merge within a Hubble time, and on the bulk abundances of tidally disrupted planetesimals.

Read more about the WEAVE-WD survey