Galactic Plane Stellar, Circumstellar and Interstellar Physics (SCIP)

A nested set of LR/HR science programmes making one overall WEAVE survey component ...mainly (not only) selected from EGAPS, targeting the Galactic Plane

SCIP footprint: LR target densities – HR areas outlined in blue

600,000-fibre initial allocation (~7%): of which ~two-thirds go to LR work, ~one-third to two HR regions

Footprint about to change: region beyond l=190 to be cut in favour of increases 90 < l < 170 coverage (→ a bit more compact)
The SCIP Team

The selection from the full list that attended a SCIP focus meeting in Barcelona ~9 months ago

…and Shoko.

The mailing list slowly grows and will be at 45 names after Christmas

Mainly drawn from Spanish/UK communities
Overall SCIP goals

• The disc of the Milky Way, now
• The young higher mass OBA stellar populations
  • OB stellar evolution inc. RSGs
  • BA stars as disc structure tracers
  • Probes of large-scale extinction, interstellar lines
  • (Cepheids)
• Survey ISM in emission: diffuse ISM, HII/PNe/SNR
• Young stars/creation of the wide-area stellar field
• Survey of end states of low-mass evolution: WD, compact binaries
Galactic disc structure and kinematics from OBA stars – complementing Gaia

Requirement: 6D phase space + uniform coverage

Gaia (2017-2022)
5D full sky coverage

WEAVE-LR (2018-2023)
RV to 3-5 km/s
(not so strongly S/N dependent)

Gaia: unprecedented accuracy in tangential velocities

Gaia accuracy in tangential velocity (units: km/s)

Gaia OBA: $\Delta V \sim 5$ km/s
1. The LR survey component

Largest target groups:

A. OBA/massive stars: 500+ fibres/pointing, whole footprint
B. The diffuse ISM, PNe and SNR: 100-200 fibres/pointing, ~2/3 footprint

The sparser object classes:

C. End-state lower mass stars, whole footprint
D. Cepheids and other variables, equatorial concentration
E. Young stars and the creation of the stellar field, >1/2 footprint

...under 100/pointing ...usually
A: OBA/massive stars across the Galactic disc

A Galactic Disc Survey

→ Comprehensive samples for improved modelling of massive-star evolution
→ Unbiased demographics: e.g. unclustered as well as clustered OB stars included
→ Collect the longest disc sightlines ...probing the ISM up to 10kpc and more
→ BA stars trace disc structure and kinematics over the large volume

Reddened/distant OB and large numbers of BA stars to be extracted from UVEX, IPHAS photometry

(Figure – courtesy of J Maiz-Apellaniz)
WEAVE @ R=5000, with 3700—9500 Å spectral coverage, can deliver

Full/uniform set of nebular diagnostics: extinction, temperatures, densities, abundances for known nebulae ... and sparse-sampled diffuse ionised ISM

Good-enough RVs (3-5 km/s) to permit placing within the context of the Galactic disc velocity field

The LR diffuse ISM programme can take a big step towards linking the sources of ionisation with the ionised ISM – new venture – complements WHAM

Approach:
• MOS fibres for sampling diffuse ISM, known large HII complexes, SNR, compact PNe
• LIFU to be deployed for larger Pnecs (poor-seeing programme)
• 1 arcsec resolution broadband and Hα (+[NII]) EGAPS imagery of the Galactic Plane, well-matched in sensitivity for WEAVE target selection.
- Gaia will identify ~400,000 white dwarfs
- Initial-final mass relation $\Rightarrow$ galactic life cycle of matter
- Luminosity function $\Rightarrow$ local star formation rate history
- WEAVE R~5000 follow-up needed for $T_{eff}$, $M_{wd}$, ages
- Galactic plane bonus: local reddening probes ($\leq$1kpc)
- (more sparse WD/BH compact binary targets to be included)
D: Cepheids – stellar physics and MW disk structure

Large, homogeneous sample needed

- Possible metallicity dependence of the PL/PW relations
  \((PL: \text{period-luminosity}; \ PW: \text{period-Wesenheit, reddening-free})\)

- Possible metallicity dependence of the Period/p factor relation
  \((Used \ in \ the \ Baade-Wesselink \ method \ to \ derive \ distances)\)

- Metallicity distribution in the MW – especially outer disc
  \(...\text{still largely undersampled}\)

- Rotation curve of the MW in the outer disc
  \(Vr \ templates \ to \ derive <Vr> \ compensate \ for \ the \ undersampling \ of \ the \ Vr \ curve\)
E: Young stars and the creation of the stellar field

Do most field stars form in dense star clusters that dissolve (as modelled, right),

Or do a large fraction form in isolated or low-density environments?

How are dense star clusters disrupted and how can their remnants be traced?

[Are the fundamental stellar parameters (mass function, binary fraction, proto-planetary disk properties) different for low and high-density star formation?]

(Figure from Bate 2012)
Cygnus-HR

Exploration of the star-forming wider Cygnus-X region between l=71 and l=83 to:

1. Survey rotational velocities, especially in the low vsini region (< 100 km/s)
2. Good statistics on stellar multiplicity
3. Accurate stellar parameters, particularly gravity → more precise radii and masses with the help of Gaia data (improving on LR)
4. Accurate abundances and spatial abundance patterns for O3-B9 stars
5. Kinematical and dynamical status of the stars and the ISM in the Cygnus region

Survey footprint with extinction contours. Black dots mark the main OB associations in the field.

HD 36591 (B1V) in the wavelength region of the WEAVE blue HR grating
Anticentre HR

- Galactic structure and dynamics toward the Anticentre from B/A stars:
  - Tracing recent star formation in the outer disc.
  - Vertical/radial metallicity gradients in the thin disc from the young population.
  - Characterize spirals, warp, flare and ripples – nature/age of Perseus, Outer arms.
  - Stellar streams with planar orbits.
- Stellar physics at intermediate masses:
  - Chemical peculiarity – dependence on age/rotation/binarity.
  - Statistics from spectroscopic binaries.
- Ongoing star formation (HII regions/YSOs).
OBA target availability – how it will change along the plane:

Inside the Solar Circle (the summer GP) ➔ O stars, reddened RSGs numerous

B stars at all longitudes, (including CBe), albeit declining

A stars at all longitudes,
Always plentiful and excellent kinematic tracers/probes of ISM

➔ no difficulty finding 500+ targets per WEAVE field across footprint

➔ essential footprint emphasises 20°<l<95° range (the main wider latitude band)

(Besancon + Sale et al extinction)
Target selection – from IPHAS/UVEX/VPHAS+ plane surveys (it works)

e.g. VPHAS+/Carina example:
Colour-colour diagram \(\rightarrow\) SED fits \(\rightarrow\)
\(~6000\) OB candidates over 42 sq. deg

&gt;95\% confirmation rate
\((Mohr-Smith\ et\ al,\ in\ press)\)

...doing nearly as well selecting (B)/A stars from \(r-H\alpha, r-i\) diagram
LR programme deliverables:

S/N requirement for $T_{\text{eff}}$, log g measures, good RVs:

30+ for OBA target group

A typical (faint-end) object: a B3V star with $A_v \sim 4$, 10kpc away would have apparent mags

B $\sim 18.5$, R $\sim 17.5$, I $\sim 17$

$\rightarrow$ B-band region: S/N $\sim 25$ or 40,
$\rightarrow$ I-band region: S/N $\sim 38$ or 55

from 1 or 2 visits, in grey/dark time

Targeting the Galactic Plane $\rightarrow$ extinction vary strongly with pointing, and can be as high as you like (Q1, b$\sim 0$)

$A_v > 5$ targets: science more reliant on the red end (CaT region) of the R=5000 wavelength range.
Compact blue objects/WD: science needs blue end, but lower S/N requirement will permit selection of fainter targets

$\cdots$ the power of WEAVE’s LR spectral coverage
The 5-year LR survey

- All Galactic longitudes from $20^\circ$ to $190^\circ$, split into sub-ranges as follows (latitude ranges $\sim$approximate):
  - $20^\circ < l < 95^\circ$, $-4^\circ < b < +4^\circ$ ($1^{st}$ quadrant)
  - $95^\circ < l < 170^\circ$, $-1^\circ < b < +3^\circ$ ($2^{nd}$ quadrant warp)
  - $170^\circ < l < 190^\circ$, $-4^\circ < b < +4^\circ$ (Anticentre)

→ Mostly single visit: some targets in $1^{st}$ quadrant to be covered twice to improve S/N, stats on binary frequency
→ ~350 tiles (field centres),
→ ~400 hours, in total
The 5-year HR surveys

Cygnus:
- S/N = 120 target
- 19 tiles, mostly visited several times (extinction dependent)
- Aims to reach to 2kpc through complex

<table>
<thead>
<tr>
<th>tiles (see Fig. 8)</th>
<th>$A_0$</th>
<th>$A_B$</th>
<th>$m_B$ for B2V at 2.0 kpc</th>
<th>$t_{exp}$ for SNR = 120 (hr)</th>
<th>proposed 1hr visits</th>
<th># fields</th>
<th>SNR reached for a B2V at 2.0 kpc</th>
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Anticentre:
- 25-30 tiles, using red+blue gratings
- 6h to achieve SNR~70 at V=16
  - A0V to 2.5kpc, B5V to 4-5 kpc
- 3 visits of 2h each to check for binarity
  - For bright stars: 3 1-hour visits
- B5-A9 stars selected using IPHAS
- Enough targets to fill all fibres.

<table>
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<tr>
<th>SNR</th>
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<th>70</th>
<th>100</th>
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<td>Logg (dex)</td>
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<td>Vsini (km/s)</td>
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<tr>
<td>RV(km/s)</td>
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