Outline

Aspects of stellar feedback and star formation:

- kinematics and energetics of star-forming regions
- heating and cooling of the ISM
- transmittance of turbulence into molecular clouds and the dilute ISM
- tracers of star formation in distant galaxies
- regulation of stellar feedback by magnetic fields
Aspects of stellar feedback and star formation:

- kinematics and energetics of star-forming regions
  ⇒ SOFIA/upGREAT

- heating and cooling of the ISM
  ⇒ SOFIA/upGREAT+HIRMES+FORCAST and JWST

- transmittance of turbulence into molecular clouds and the dilute ISM
  ⇒ SOFIA/upGREAT+HIRMES+EXES and ALMA

- tracers of star formation in distant galaxies
  ⇒ SOFIA/upGREAT+HIRMES+FIFI-LS

- regulation of stellar feedback by magnetic fields
  ⇒ SOFIA/HAWC+
Disruption of the Orion molecular core 1 by wind from the massive star θ¹ Orionis C


Figure 1: Three infrared images of the Orion Nebula complex (Pabst+2019). a) Herschel/PACS and SPIRE dust continuum images (red: SPIRE 250 µm, green: PACS 160 µm, blue: PACS 70 µm). b) Line-integrated [C II] 158 µm emission, observed by the upGREAT instrument onboard SOFIA. c) Spitzer/IRAC 8 µm image.

Figure 2: \([\text{C} \text{\textsc{ii}}]\) pv diagram through the Orion Veil shell (Pabst+2019, Pabst+2020). The lower panel traces the arc structure for an expansion velocity of 13 km s\(^{-1}\) on a background velocity of 8 km s\(^{-1}\) (red dashed lines).
Turbulence and hydrodynamic instabilities

Figure 3: Three-color image of [C II] velocity channels of the southern Veil shell (Pabst+2020). Blue: $v_{\text{LSR}} = 0-2 \text{ km s}^{-1}$, green: $v_{\text{LSR}} = 4-6 \text{ km s}^{-1}$, red: $v_{\text{LSR}} = 8-10 \text{ km s}^{-1}$. The spectra were extracted towards the areas indicated by the numbered circles.

Figure 4: [C II] spectra towards the Veil shell. Each spectrum is averaged over a circle with a radius of $40''$. Each spectrum consists of multiple line components, which is characteristic of thermodynamic instabilities.
Filaments and molecular globules in Orion

Figure 5: ALMA and IRAM 30m observations towards Orion (Hacar+2018, Goicoechea+2016, Goicoechea+2020)
Heating and cooling: efficiency and PAH properties

**Figure 6:** PAH properties in NGC 7023 (Croiset+2016)

**Figure 7:** PAH properties in Orion (Knight+submitted, cf. Boersma+2012)
Star-formation tracers of the distant universe

Figure 8: [O I] 63 µm and [C II] 158 µm as tracers of star formation (and local conditions). Left: Rybak+2020 for z ~ 6 dusty star-forming galaxy, right: Pabst+ in prep. for Orion Nebula.
The $1,000,000$ Question:

What about magnetic fields?
Magnetic Orion

Figure 9: Magnetic field lines in OMC1 (APOD, Chuss+2019).

Figure 10: Magnetic field lines in the Veil?
Summary

- [C II] map of Orion is an incredibly rich data set, many as yet unexplored features
- need to map large regions at high spectral and spatial resolution efficiently
- a HIRMES-like instrument could provide this for the [O I], [O III] and [N II] FIR lines
- SOFIA can map the two most important FIR cooling lines of the ISM at high spectral and angular resolution
- SOFIA can quantify stellar feedback (ongoing: FEEDBACK C+ Legacy Program)
- SOFIA observations help constrain physical conditions in the ISM
- SOFIA can map PAH properties within a large FoV
- SOFIA helps understand the role magnetic fields play in regulating star formation
- SOFIA provides the “local truth” for star-formation tracers in the distant universe