EPOS – A Herschel Key Program on the Earliest Phases Of Star-Formation

Oliver Krause
Max-Planck-Institute for Astronomy, Heidelberg

H. Beuther, T. Henning, R. Launhardt, H. Linz, M. Nielbock, S. Ragan, A. Stutz (MPIA), M. Hennemann, P. André (CEA-Saclay), S. Birkmann (ESTEC), B. Stecklum (Tautenburg), J. Steinacker (Paris)
HERSCHEL is now in routine-observing phase

All three instruments in excellent condition - providing 55-670 $\mu$m spectral coverage

3.5m $\rightarrow$ 5.2" @ 70 $\mu$m

Expect call for open time proposals on 20/05/10 (due on 22/07/10)
EPOS Science Goal

Temperature & density structure of low- to high-mass prestellar cores / protostellar objects

Strategy: Follow-up observations of 60 objects with extensive sets of multi-wavelength ancillary data (no blind survey such as HiGAL – see talk by Sergio Molinari on Thursday – or Cold Planck Cores)

- 45 high-mass objects based on (I) cold ISO 170 µm sources, (II) IRDCs, and (III) submm surveys
- 15 isolated low-mass cores in low background regions

Herschel observations: 70, 100, 160, 250, 350, 500 µm scan maps
Cold ISOSS Source J18364-0221

3200 $M_\odot$ cloud complex
$D = 2.2$ kpc
$T(NH_3) = 11.6$ K
ISOSS J18364-0221N/S: Two high-mass protostars with collimated outflows

Birkmann et al. 2006

Hennemann et al. 2009
Zooming in: 8-1200 µm imaging of the two protostars SMM1N/S
Spectral energy distributions of SMM1N/S

Peak column densities

$n(H) = 3 \times 10^{23} \text{ cm}^{-2}$

Herschel

Spitzer

$\sigma$ upper limits

Wavelength in $\mu$m

$\nu F_\nu$ in W/m$^2$

$T_{\text{warm}} = 48K$

$M_{\text{warm}} = 0.05M_\odot$

$T_{\text{cold}} = 22K$

$M_{\text{cold}} = 12M_\odot$

SMM1 South x 10

SMM1 North

$T = 15K$

$M = 18M_\odot$
NIR Extinction vs. FIR Emission

NICER extinction map from Calar Alto 3.5m data

Birkinmann et al. 2004
Comparison $n(A_K) - n(\text{FIR/submm})$
IRDC G11.11: The "Snake" as seen by Herschel

Henning, Ragan, Linz et al.
Embedded protostars in the IRDC G11.11-0.12

MIPS 24 µm  PACS 70 µm  PACS 100 µm

PACS 160 µm  SPIRE 350 µm  SCUBA 850 µm
High-Mass Star Formation Complex I18223

High-Mass Core with embedded low- to intermediate-mass Protostar destined to become massive at end of evolution.

Beuther et al.
High-mass starless cores
High-mass core with embedded protostellar object

2 component fit
T=17 & >42K
L_{tot}=596L_{sun}

T>42K
M>0.08M_{sun}
L=12L_{sun}

IRDC18223-3
dark until 8\mu m

Spitzer IRAC 3.3, 4.5 & 8 \mu m

Rotational structure

Contours: 1.1mm dust continuum

\Delta dec. ["]

\Delta R.A. ["]

\Delta R.A. ["]

\Delta dec. ["]

Fallscheer et al. 2009; see also Cassie’s talk on I18223 this afternoon
High-mass protostellar object (IRAS18223-1243)
CB 244 (L1261)

- $D \sim 200$ pc
- $M \sim 14 \, M_\odot$
- 2 Cores:
  - 1 Class 0 YSO
  - 1 "pre-stellar" core

Stutz, Launhardt et al.

More on 8 and 24 um shadows on Amy Stutz’s poster BP3
CB244: Dust temperature structure measured with Herschel

Grey-body $\chi^2$ fit to all points $\lambda > 60\mu$m ($\beta = 1.5$, fit for $T_d$ and $\tau$)

$M = 3.6 M_\odot$

$M = 1.6 M_\odot$

2: Prestellar core

1: Protostar

$T_d$ [K]

$\lambda$ [\mu m]

$\log \nu$ [Hz]

$S_m$ [10^{-3} W m^{-2} \mu m^{-1}]$
Conclusions

• The superb spatial resolution and spectral coverage of HERSCHEL in the FIR provide a new opportunity to better constrain the earliest phases of star formation by measuring the peak of thermal dust emission

• First results from Herschel are expected on astro-ph end of May – stay tuned and get ready for your own HERSCHEL proposal in July 2010!