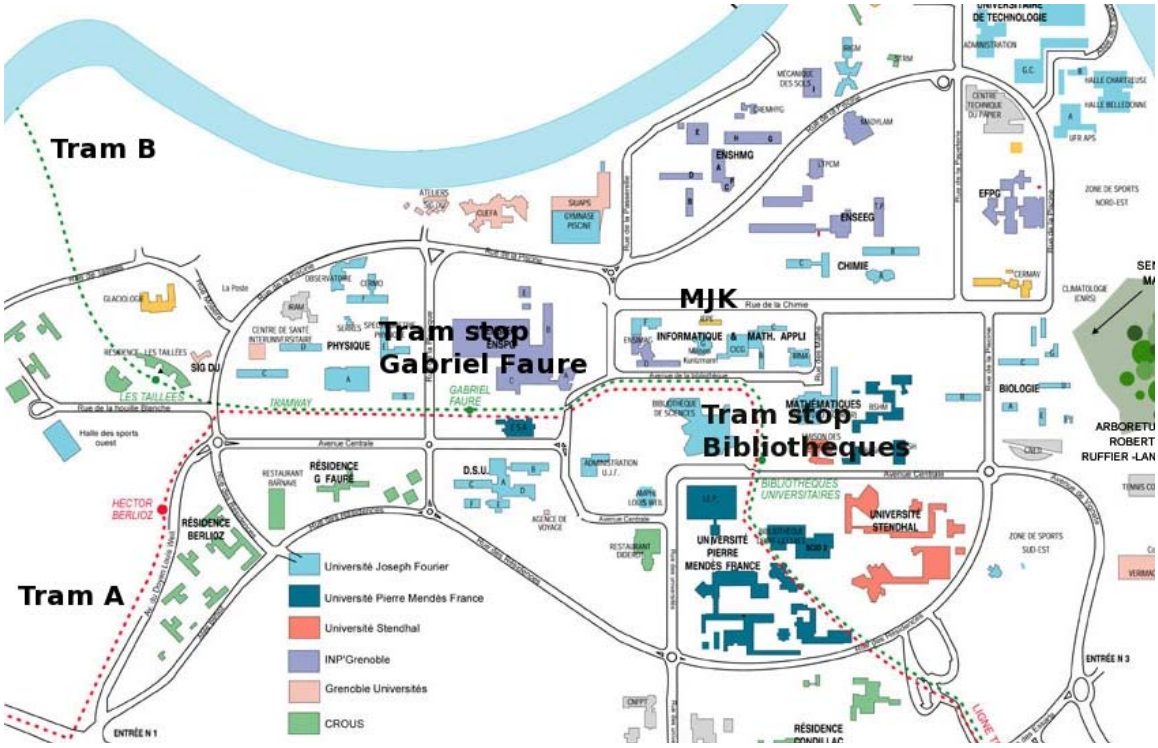
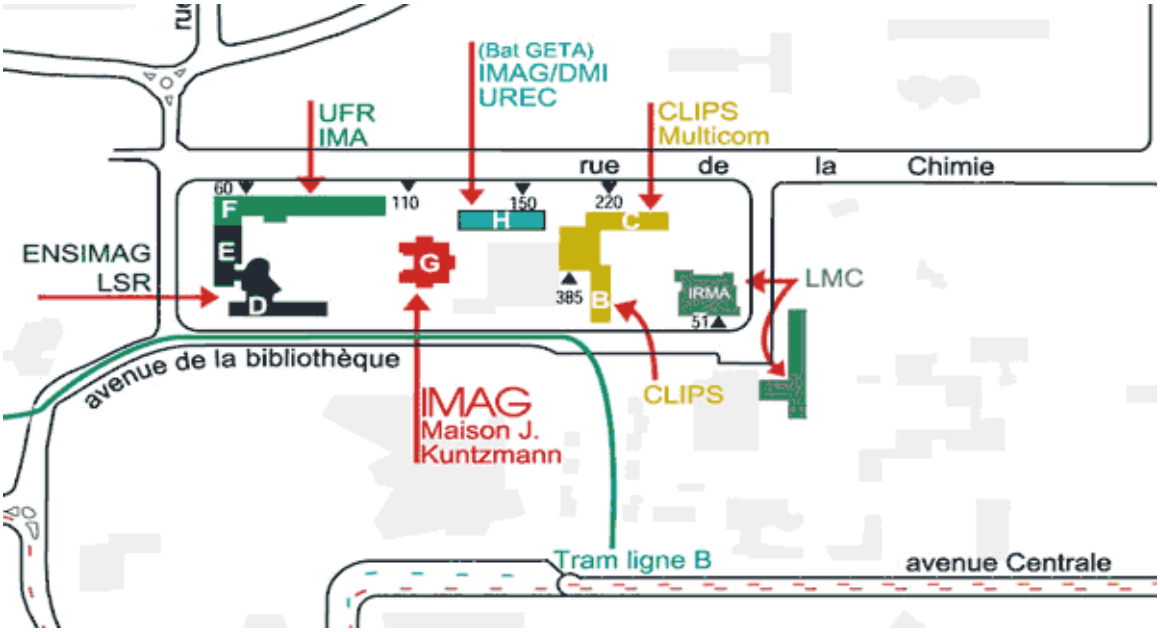
# Constellation WP3 Progress Meeting
# Grenoble, 6-7 January 2009

Location : **Maison Jean Kunzman**, 110 Avenue de la Chimie, Campus Universitaire, Saint Martin d'Hères

To get there (about 20 min from downtown by tram): Tram line B , direction "Gieres, Plaine des sports", or Tram line C, direction "Condillac, Universites"; in both cases stop at « Gabriel Faure » or at "Bibliotheques Universitaires", then see maps :






The meeting will take place on the University campus, on January 6-7, from 9am to 5pm. A list of hotels in Grenoble can be found on the web site of the Tourist Office (http://www.grenoble-isere-tourisme.com/english/default.asp). I would recommend hotels located downtown rather than those near the campus (15 min away by tram).

## Registered Participants

**Exeter :** Suzanne Aigrain, Catia Cardoso (ESR), Robert King, Mark McCaughrean, Elaine Winston (ER)

**Arcertri :** Elisabetta Rigliaco

**Prague :** -

**Potsdam :** -

**Saclay :** Philippe André, Timea Csengeri (ESR), Vera Konyves (ER), Patrick Hennebelle

**Cardiff :** Dimitris Stamatellos, Stefanie Walch (ER), Anthony Whitworth

**Sheffield :** Simon Goodwin, Richard Parker

**Lyon :** Alberic Joos (ESR)

**Lisboa :** -

**IAC :** Nicolas Lodieu, Manuel Perger (ESR), Basmah Riaz (ER)

**LAOG :** Catarina Alves de Oliveira (ER), Jerome Bouvier, Andrew Burgess (ESR), Catherine Dougados, Francois Menard, Jean-Louis Monin, Estelle Moraux

**Palermo :** Ella Hopewell (ER), Giusi Micela

**Cambrigde :** Simon Hodgkin

**St Andrews :** -

# Goal : review current progress, on-going projects, and prospects related to WP3 "The physics of the low-mass end of the IMF "

Over the 2 days, we plan to devote half of the time for (short) presentations and the other half for (long) discussions. The aim of this meeting is to have a clear view of what collaborative projects are being pursued and/or should be developed in the framework of WP3 for the next 2 years of the network's life.

**Topics to be discussed (among others…)**

(i) The latest observational results regarding the distribution and velocity dispersion of brown dwarfs (and planemos and very low-mass hydrogen-burning stars) in young star formation regions, and the implications for theory.

(ii) The effect of treating radiative feedback and the transport of cooling radiation on simulations of star formation, and in particular on the low-mass end of the IMF.

(iii) What are the prospects for distinguishing observationally a planetary-mass star (formed by gravitational instability, on a dynamical timescale and with an homogeneous elemental composition) from a true planet (formed by core accretion etc, on a much longer timescale, and with an initially fractionated elemental composition).

## Programme

**Tuesday, Jan.6 : Presentations (20 min + 10 min)**

9h00 Welcome

9h30 **P. Hennebelle** (Saclay)
*An analytical model for the theory of the initial mass function*

10h00 **M. Perger** (IAC)
*A UKIDSS-based Search for Very Low-Mass Stars and Brown Dwarfs in Taurus-Auriga*

10h30 Coffee break

11h00 **E. Rigliaco** (Arcetri)
*The photoevaporation of an evolved disk in sigma Ori*

11h30 **B. Riaz** (IAC)
*A study of a low-mass protostellar system in the B59 molecular cloud*

12h00 **A. Whitworth** (Cardiff)
*The formation and dispersal of brown dwarfs*

12h30 Lunch break (on site)

14h00 **D. Stamatellos** (Cardiff)
*The properties of extremely low-mass stars formed by disc fragmentation*

14h30 **Ph. André** (Saclay)
*Searching for low-mass prestellar cores with Herschel*

15h00 **S. Walch** (Cardiff)
*Low mass star formation from collapsing prestellar molecular cloud cores.*

15h30 Coffee Break

16h00 **E. Winston** (Exeter)
*A Spectroscopic Survey of YSOs in Serpens and NGC 1333.*

16h30 **A. Burgess** (Grenoble)
*Three New T-Dwarfs in the Star Forming Region IC 348*

17h00 **C. Alves de Oliveira** (Grenoble)
*IR observations of the Rho Ophiuchi molecular cloud*

17h30 **J.-L. Monin** (Grenoble)
*Disk emission across the stellar/substellar boundary in Taurus*

**Wednesday, Jan.7 : Discussions**

9h00 **Simon Goodwin** (Sheffield)
WP3 theory: achievements and prospects

9h45 **Jerome Bouvier** (Grenoble)
WP3 observations: achievements and prospects

10h30 Coffee break

11h00 **General discussion**

12h30 Lunch break (on site)

14h00 **Sub-group discussions, coordination, etc. ?**

17h00 End

## Abstracts

**P. Hennebelle** (Saclay)
*An analytical model for the theory of the initial mass function*

I will present an analytical model which aim at deriving the initial mass function. The model which is based on the gravo-turbulent picture and the interplay between turbulent compression, turbulent support and gravity, used the Press & Schecter formalism developed in Cosmology. Detailed comparisons between the theoretical prediction and the Chabrier's IMF show a good agreement.

**M. Perger** (IAC)
*A UKIDSS-based Search for Very Low-Mass Stars and Brown Dwarfs in Taurus-Auriga*

The near-infrared (ZYJHK bands) UKIDSS GCS survey covers a yet unexplored area of the Taurus-Auriga star forming region. An infrared extinction map has been constructed using the UKIDSS data. Then, a search for very low-mass stars and brown dwarfs has been made via color- and proper motion membership criteria derived by comparing 2MASS and UKIDSS data. Over 50 candidates have been found that meet our color and proper motion selection criteria. A few T-type candidates have been selected just from the UKIDSS photometry. Spectroscopic follow-up of our candidates has already started at Lick and La Palma observatories.

**E. Rigliaco** (Arcetri)
*The photoevaporation of an evolved disk in sigma Ori*

The low-mass T Tauri star SO587 (Hernandez et al.~2006) in the sigma Ori cluster is surrounded by an evolved disk, with no evidence for any large inner hole. The accretion rate onto the central star is very low. Nonetheless, strong forbidden lines of [SII], [NII] and [OI] are present in its optical spectrum, which, interpreted as coming from a jet/wind, as in typical T tauri stars, requires a mass-loss rate of ~ 10^{-8} Msun/y, i.e., a ratio Mwind/Macc ~ 10. Such a high ratio excludes all accretion-driven mass-loss mechanisms. We suggest that the forbidden lines are coming instead from the photoevaporation of the outer disk due to the TTS itself or due to the bright and hot star sigma Ori. This slow, neutral outflow, which is generally very hard to detect, stands out in SO587 because of the effect of the nearby bright star sigma Ori itself, which ionizes and heats it. We discuss the plausibility of this model and speculate briefly on the possibility that grain growth, suggested by the steep SED of SO587, plays a role.

**B. Riaz** (IAC)
*A study of a low-mass protostellar system in the B59 molecular cloud*

We present near-infrared observations of the low-mass deeply-embedded Class 0/I system 2MASS J17112318-2724315 (2M171123) in the B59 molecular cloud. Bright scattered light nebulosity is observed towards this source in the Ks images, that seems to trace the edges of an outflow cavity. An interesting feature observed is a dark shadowed lane that lies completely offset from the system. This suggests a morphology in which the protostar casts a shadow onto a nearby optically thick background cloud. We report the detection of a new faint source 2M17112255-27243448 (2M17112255), ~8" (~1000 AU) from 2M171123. The mass for 2M17112255 as estimated from evolutionary models is found to be between 5 and 13 M_JUP, at an age of 1 Myr, indicating it to be a planetary mass/substellar object. This is the first such detection in the B59 molecular cloud. We also present detailed modeling of the 2M171123 system. The best-fit parameters indicate a large envelope density of the order of ~10E-13 g/cm3, and an intermediate inclination angle of ~56deg. We find a slight variability in the mass infall rate between 2.5E-5 and 1.8E-5 Msun/yr, that could explain the observed Ks-band variability for 2M171123. This protostar exhibits a rarely observed absorption feature near 11.3 micron within its 10 micron silicate band. In exploring the possible origins of this feature, we find a strong correlation between the strength in the 11.3 micron shoulder and the H2O-ice column density. A comparison with other low-mass protostars shows that objects that are not deeply embedded or have heated their envelopes sufficiently to melt away a large fraction of the ice coatings exhibit a weaker strength in the 11.3 micron shoulder, indicating the origin of this feature in the thickness of the ice mantle over the silicate grains.

**A. Whitworth** (Cardiff)
*The formation and dispersal of brown dwarfs*

I will summarise the analytic and numerical work we have done in Cardiff on the formation of brown dwarfs by disc fragmentation, (Subsequently Dimitri will present the statistical results, and compare them with observation.) I will discuss various technical advances which we have made or are pursuing, which will help us to capture the critical physics, by treating the energy equation, the associated transport of cooling radiation, and radiative and mechanical feedback, more realistically. I will describe an ongoing project to shed more light on the velocity dispersion and clustering properties of brown dwarfs.

**D. Stamatellos** (Cardiff)
*The properties of extremely low-mass stars formed by disc fragmentation*

We suggest that stars like the Sun should sometimes form with massive (a few 0.1Msun), extended (a few hundred AU) discs, and we show by means of radiative hydrodynamic simulations that the outer parts (>100 AU) of such discs are likely to fragment on a dynamical time-scale, forming extremely low-mass stars: principally brown dwarfs, but also low-mass hydrogen-burning stars and planetary-mass objects. I will present the predictions of this model on the mass distribution of the stars formed, their orbital properties (semi-major axis, eccentricity, orbital plane), and their binary properties, and I will compare these properties with the observed properties of low-mass stars. I will show that the formation of low- mass stars by disc fragmentation explains the brown dwarf desert and the binary properties of low-mass stars.

**Ph. André (Saclay)**
*Searching for low-mass prestellar cores with Herschel*

The Herschel Space Observatory to be launched in April 2009 will provide a unique opportunity to improve our global understanding of the early phases of star formation. As prestellar cores and young protostars emit the bulk of their luminosity at ~ 80-400 microns, the SPIRE and PACS bolometer arrays on Herschel are ideal for taking a complete census of these objects down to ~ 0.01-0.1 Msun in nearby (< 0.5 kpc) molecular cloud complexes. I will present the objectives of the Herschel survey of the Gould Belt, which is an approved key project led by the Saclay node. Expected immediate outcomes include an accurate prestellar core mass function from the proto-brown-dwarf to the intermediate-mass regime, as well as large samples of dense cores and protostars with well characterized luminosities, temperatures, and masses up to the high-mass regime. In particular, this Herschel survey should allow us to determine whether a large fraction of brown dwarfs can form from the collapse of ultra-low-mass prestellar cores.

**S. Walch (Cardiff)**
*Low mass star formation from collapsing prestellar molecular cloud cores.*

The collapse of low-mass prestellar cores, as well as the formation and early evolution of protostellar disks is investigated in fully 3D SPH simulations. We start from mildly turbulent Bonnor-Ebert spheres or spheres in rigid rotation of various speed, representing different total angular momenta of the cores. We find that disks forming from cores with low angular momenta are moderately sized ($<$100-200AU), highly concentrated and warm. They are stable against local gravitational instabilities, e.g. fragmentation. Heating by accretion and infall plays a major role in stabilising the disk. On the other hand, more

rapidly rotating cores form more extended disks (500-1000AU), which are less concentrated and cooler. They show extended spiral arm structures and are undergoing fragmentation. These fragments, which are themselves surrounded by small ($~$50AU) 'circumfragmentary' disks, may evolve into brown dwarfs or very low mass stars.

**E. Winston (Exeter)**
*A Spectroscopic Survey of YSOs in Serpens and NGC 1333.*

I present spectral observations of 140 young stellar objects (YSOs) in the Serpens Cloud Core and NGC 1333 star forming regions, using near-IR spectra in the H, and K-bands from SpeX on the IRTF, and far-red spectra (6000 - 9000 A) from Hectospec on the MMT. These YSOs were identified in previous Spitzer and Chandra observations, and the evolutionary classes of the YSOs were determined from the Spitzer mid-IR photometry. With these spectra, we search for corroborating evidence for the pre-Main Sequence nature of the objects, study the properties of the detected emission lines as a function of evolutionary class, and obtain spectral types for the observed YSOs. By comparing the positions of the YSOs in the HR diagrams with the pre-main sequence tracks, we determine ages of the embedded sources and study the relative ages of the YSOs with and without optically thick circumstellar disks, and find them to be similarly distributed. We examine the spatial distribution and extinction of the YSOs as a function of their isochronal ages. We find the sources < 3 Myr to be concentrated in the molecular cloud gas while the older sources are spatially dispersed and are not deeply embedded. The variation in X-ray flux, FX , with evolutionary class indicates that the Class II sources in both clusters were slightly more luminous than the Class III stars. The X-ray flux was found to depend on the calculated bolometric luminosity.

**A. Burgess (Grenoble)**
*Three New T-Dwarfs in the Star Forming Region IC 348*

Utilising 1x1degree MEGACAM and the 20'x20' WIRCAM instruments on the CFHT, z-band and J, H, K, and narrowband methane 'on/off' images were taken of the Star Forming Region IC 348. Catalogues for each band were extracted using the methane 'off' image as the detection image, ensuring unambiguous comparison with the methane 'on' image. The criteria for candidate selection depends on the level of methane present in the atmosphere of these young and cool objects. A methane absorption with colour on-off>0.4mag agreed with T-dwarf models and was applied to the sample. From the 135 objects with on-off>0.4mag which were examined visually, three objects passed the colour/colour and colour/magnitude diagram selection process. Extinction is estimated to be between 5 and 11 magnitudes when dereddened to the COND 3Myr model, yet also depending on the location in the cluster. These objects are estimated to have temperature and mass characteristic of T3-T5 dwarfs, according to DUSTY and COND models, making them among the lowest mass objects found in a star forming region.

**C. Alves de Oliveira** (Grenoble)
*IR observations of the Rho Ophiuchi molecular cloud*

The Rho Ophiuchi molecular cloud is one of the nearest star forming regions, and therefore widely studied. Despite its proximity, few stars are optically observed due to the high visual extinction in the core. Only recently, with the development of wide-field IR instrumentation, it became possible to study the embedded low mass population of this cluster down to unprecedented magnitude limits. Two projects that explore this new possibility will be presented: a near-IR variability study of young stellar objects targeting the Ophiuchus molecular cloud, using WFCAM/UKIRT multi-epoch observations; and a deep wide-field survey of the same star forming region with WIRCAM/CFHT and the prospects for a large spectroscopic follow-up which could provide a complete census of the cluster's low mass population.

**J.-L. Monin** (Grenoble)
*Disk emission across the stellar/substellar boundary in Taurus*

With submillimeter and millimeter observations we are investigating the presence and properties of disks around low mass stars and brown dwarfs. Our work extends the results of previous surveys of disks around higher mass Taurus members. While the submm flux shows no clear trend with spectral type through the early-M stars, the fluxes decline at the latest spectral classes. We combine the 350um and 1mm measurements to model the spectral energy distribution and estimate the disk masses and dust opacity power law index.