Olivier Chesneau’s Work on low mass stars

Eric Lagadec
(Observatoire de la Côte d’Azur)
Olivier’s path to the stars
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Evolved stars

Mass loss and circumstellar environments
A network of more than 200 collaborators

France, Germany, Nederlands, Belgium, Switzeland, Italy, Czech Republic, UK, Spain, Canada, USA, Chile, Brasil, Argentina, South Africa, India, Australia ...
Morphologies of AGB and post-AGB envelopes

80% of PNe are non-spherical! (Balick 2002)

Almost no PPNe are spherical! (Sahai 1998, Lagadec 2011)

AGB star

Different PNe
Shaping of the envelopes by a binary companion?
Need for equatorial overdensities

PNe shaping models (Balick & Frank 2002)
Multipolar jets: precession?

- Sahai & Trauger 1998: A disc is not enough, need precessing jets
- Corradi 2007
Outflow/jets momentum

- **Bujarrabal et al. 2001**: 28/32 Post-AGB stars (PPNe) showing CO emission, have outflow momenta in excess to what radiation can provide.
Formation of a bipolar/multipolar PN

- Long debate binary vs magnetic field

Debate settled during a football game in La Palma (APN4, 2007)
Formation of a bipolar/multipolar PN

• Long debate binary vs magnetic field
• Soker (2005): a single star can not supply enough energy and angular momentum to shape those nebulae
• Nordhaus et al. (2006): magnetic fields can play an important role but isolated stars can not sustain a magnetic field for long enough
Direct detection of binaries

- High angular resolution techniques (AO, interferometry, lucky imaging…)
- Olivier was hoping to directly image binaries with AO or interferometry

Problems:

- AO: limited angular resolution
- Interferometry: limited sensitivity and baselines
Olivier’s “toys”

- **NACO/VLT**
  - Near-IR Adaptive Optics imaging, spatial resolution 60 mas
  - Burst mode: images of 10-50ms
- **VISIR/VLT**
  - Mid-IR imaging, spatial resolution 250 mas
  - Burst mode: images of 5-50ms
- **MIDI/VLTI**
  - Direct recombination N (8-13mm), R=30,230, spatial resolution 10 mas (10 AU/1kpc)
  - Sensitivity lim: N<4 (UTs)!
- **AMBER/VLTI**
  - Near-IR recombiner (1-2.5mm), R=35, 1500, 12000, spatial resolution 2 mas (2 AU/1kpc)
  - Sensitivity lim: K<7 (UTs), R=35
First search for disks with MIDI

Torus resolved without interferometry

Complex morphology: interpretation?

Lagadec et al., 2006 (VLT/IR)

Chesneau et al., 2007 (HST/Hα)
High-Resolution view of CPD-568032

10 μm image

8.7 μm image (30% PAHs)
Detection of discs with MIDI

A disc!!!!!

Olivier: the disc hunter with MIDI

- CPD -568032, Chesneau et al., 2007
- Hen 2-113, Lagadec et al., 2006
- Mz 3, The Ant, Chesneau et al., 2007
- QX Pup, the Rotten Egg
- M2-9, The Butterfly, Lykou et al., 2010

Additional references:
- Chesneau et al., 2007
- Lagadec et al., 2006
- Matsuura et al., 2006
- Lykou et al., 2010

MIDI visibilities for different baselines orientations.
- Massive (1 solar mass for NGC 6302)
- Slow expansion, limited angular momentum
- If gas supply ceases: structure slowly vanishes

Peretto et al., 2007 (JCMT/mm)  Lagadec et al., 2006 (VLT/IR)
Stratified disks

- Clear vertical stratification
- Small aperture angle (<10 degrees)
- Keplerian rotation (longer lifetime)

Isella et al., 2006 (YSO)
My personal opinion is that the discovery of a stratified disk with proved Keplerian kinematics is directly connected to the influence of a companion, albeit the few exceptions presented above, namely the Young Stellar Objects or the critical velocity rotating massive sources such as Be stars. This hypothesis must be confirmed by further observations.

Olivier Chesneau
Born-again stars

Cool red giant → Star ejects outer layers → Reborn giant → Star ejects outer layers

Planetary nebula and central white dwarf → New planetary nebula inside original

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Sakurai’s object: a Very Late Thermal Pulse

MIDI observations in 2007
MIDI structure coincident with PN
Fit very difficult: complex geometry.
Equatorial overdensity → disk in formation?

Novae with interferometry

What is the distance to the source?
Is the outburst spherical?
Is the nova wind spherical?
How can dust form?

~ 1 event per year
Nova V1280 Sco: MIDI observations just after the event

Fast dust creation! ($10^{-6} \, M_\odot$ in 140 days)

Expansion: 0.35mas per day

Chesneau et al., 2008
Nova V1280 Sco: Live formation of a bipolar nebula

Chesneau et al., 2012
His final works

V854 Cen

The R CrB star V854 Cen is surrounded by a hot dusty disk

O. Chesneau\(^1\), F. Millour\(^1\), O. De Marco\(^2\), S. Bright\(^1,2\), A. Spang\(^1\), E. Lagadec\(^1\), D. Mekarnia\(^1\), and W. J. de Wit\(^3,4\)
SPHERE/VLT: one of his next projects
SPHERE/VLT: Betelgeuse

Cntr Halpa 645 nm

Narrow Halpa 656.3 nm
SPHERE/VLT: Betelgeuse
SPHERE/VLT: Betelgeuse
The AGB star L2 Pup: A bipolar PN in the making!
The AGB star L2 Pup: A bipolar PN in the making!
« My dad now lives on his asteroid and is wandering to visit his favourite stars. He is happy because he now has answers to all the questions he had. »

Mathieu Chesneau
Olivier Chesneau

The Little Prince of astronomy
Memories

Livre édité par Lagrange / OCA
Merci Olivier!
Merci Olivier!

Please send us answers to these questions!
Different types of binary interactions

- tidal interaction
- wind accretion & tidally enhanced winds
- Roche-lobe overflow
- common envelope evolution

Figure from Pols, 2005
Two rings (short mass loss episodes)

Dynamical imprint: presence of a binary system (P=90 yr)

Lykou, Chesneau et al. 2011