The timescale of mass accretion

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Outline

- **Introduction**
  - Dissipation of inner disk
- **Mass accretion evolution**
- **Results**
- **Comparison $M_{acc}$ – NIR excess evolution**
- **Conclusions**
NIR excess decay in PMSs

- Signature of dust dissipation
- $\tau_{\text{NIR}} \sim 5 - 9$ Myr
  - binarity is important

Haisch, Lada & Lada 2001, Hillenbrand 2006
Clearing of inner disk - I

- Viscous accretion + Photoevaporation (e.g. Clarke et al. 2001, Alexander et al. 2005)

Mass accretion decreases with time as expected for viscous evolution. When $M_{\text{acc}} \sim \text{photoevaporative wind}$, stop of supply of material to the inner disk ($< R_g$). Inner disk drains on viscous timescale.
Clearing of inner disk - II

- Formation of giant planets (e.g. Lin & Papaloizou 1979, Rice et al. 2003, Quillen et al. 2004)
  - Gap opening due to planet-disk tidal interaction;
  - Transitional objects (Najita et al. 2007, Alexander & Armitage 2007)
Clearing of inner disk – dust vs gas

- $\tau_{\text{NIR}}$ relies on dust evolution only;
- What about gas evolution?
  - Disk initial mass in gaseous state (~ 99%, ISM)
  - Gas impacts dust dynamics and settling
  - Set disk lifetime and timescale for giant planet formation
Clearing of inner disk – gas

- Gas emission from disk is difficult to trace;
- \([\text{OI}], \ CO, \ H_2, \ [\text{NeII}], \ldots\)
  - Strongly dependent on physical conditions (e.g. UV field)
  - Weak
  - Trace only part of the disk (e.g. optically thin regions, disk upper layers)
Clearing of inner disk - gas

- Measure of mass accretion timescale ($\tau_{\text{acc}}$)
- $M_{\text{acc}} \propto \Sigma(R) \rightarrow$ disk mass
- $\tau_{\text{acc}} \leq \tau_{\text{gas}}$ (Gas dissipation timescale in inner disk)
- Easier to trace compared to $H_2$, CO, [NeII] …
Accretion timescale: Observing strategy

- **MOS with VIMOS/VLT**
- **Search for accretion signature (H\(\alpha\)10%) in young clusters**
- **Previous works biased towards H\(\alpha\) emitting sources !!!**
- **Derive fraction of contaminants using star counts**
- **Li 6707 Å, IR excess and X-ray to check star counts results**
**Accretion signature – Hα10%**

White & Basri 2003

Natta et al. 2004
Accretion vs Chromospheric activity

$Ha_{10\%} = 730 \text{ km s}^{-1}$

$M_{\text{acc}} = 1.6 \times 10^{-6} M_{\odot} \text{ yr}^{-1}$

$Ha_{10\%} = 170 \text{ km s}^{-1}$
Mass accretion evolution

Fedele et al. in prep.
Mohanty et al ’05
Jayawardhana et al ’06
Dahm & Hillenbrand ’06
Barrado y Navascues & Martin ‘03
Results I

i. Fraction of accreting stars per cluster ($f_{\text{acc}}$) decreases with age;

ii. $f_{\text{acc}} \sim 15\%$ at $3 - 4$ Myr;

iii. $f_{\text{acc}} < 10\%$ at $\sim 5$ Myr

iv. $f_{\text{acc}} = 0\%$ beyond $10$ Myr

v. low $f_{\text{acc}}$ in $\rho$ Oph (1 Myr), embedded population (?)
Results II

1. Fraction of accreting stars per cluster ($f_{\text{acc}}$) decreases with age
2. $f_{\text{acc}} \sim 15 - 20\%$ at $3 - 4$ Myr
3. $f_{\text{acc}} < 10\%$ at $\sim 5$ Myr
4. $f_{\text{acc}} = 0\%$ beyond $10$ Myr
5. Low $f_{\text{acc}}$ in $\rho$ Oph (1 Myr)
6. $M_{\text{acc}}$ decay similar to NIR excess, but:
   - $f_{\text{acc}} < f_{\text{NIR}} (< 5$ Myr$)$
   - $f_{\text{acc}} \sim f_{\text{NIR}} (> 5$ Myr$)$
7. $M_{\text{acc}}$ stops earlier than dust in inner disk is dissipated (independently from $\sigma_{\text{age}}$)
Possible scenarios

😊 **Gas is dissipated faster than dust**
(e.g.) as a consequence of viscous accretion + photoevaporation (“UV-switch” model)

😊 **Gas is still present but mass accretion stops**
As disk evolves, viscosity is drastically reduced and no longer disk instability (e.g. MRI, GI) occurs

😊 **Planet formation reduces gas reservoir / stops accretion** (e.g. Thommes, Matsamura & Rasio 2008)
Summary

1. $f_{\text{acc}}$ decreases with age
2. $f_{\text{acc}} < 10\%$ at $\sim 5$ Myr
3. $f_{\text{acc}} = 0\%$ ($> 10$ Myr)
4. $M_{\text{acc}}$ stops earlier than dust dissipation in inner disk