
NGC 3631
Spiral density waves
• The theory of spiral density waves was proposed by Lin & Shu (1964) to explain the observed long-live spiral patterns in spiral galaxies. It posits a spiral stationary pattern moving at a constant Ω_p where dust and gas pile up (vs. material arms in a differentially rotating disk that would "wound up" in a few rotation periods).
• Self-gravity of the spiral surface density distribution was a key ingredient to produce the self-consistent spiral pattern.
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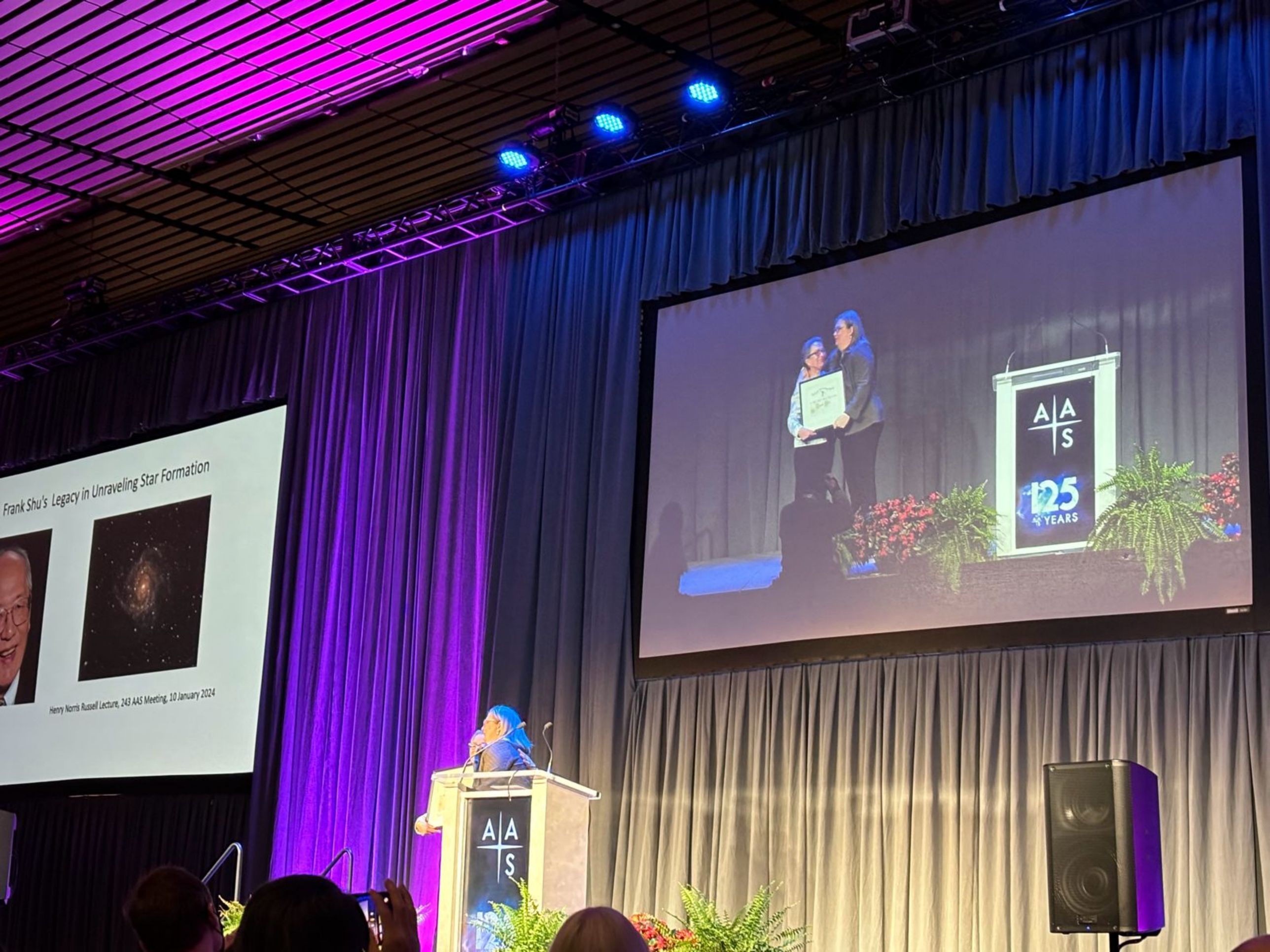
Frank Shu's Legacy in Unraveling Star Formation
Henry Norris Russell Lecture, 243 AAS Meeting, 10 January 2024
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Four stages of star formation
Shu, Adams & Lizano (1987) proposed the 4 stages of the star formation process.
At the time, this scenario provided a physical interpretation to very distinct observations, explaining the different phases of evolution of the new born stars.
This scenario became the paradigm of the formation of Sun-like stars.
Over the years, our understanding of the star formation process has evolved, revealing additional complexities. Despite these intricacies, the conceptual framework provided by the Shu 87 scenario has been instrumental in interpreting observations for over three decades.
a
b
c
d
Shu, Adams & Lizano 1987
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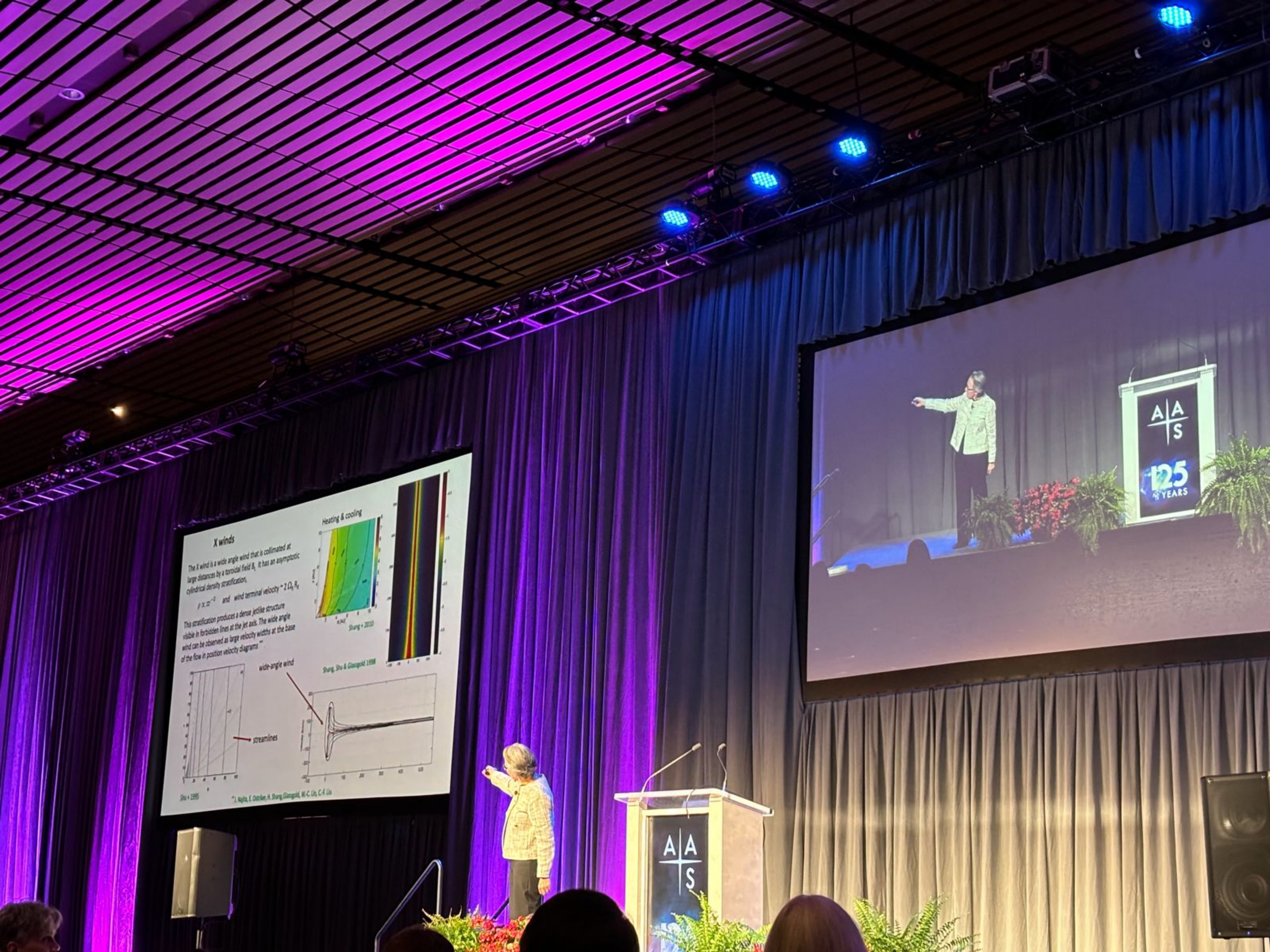
X winds
The X wind is a wide angle wind that is collimated at large distances by a toroidal field B_ϕ. It has an asymptotic cylindrical density stratification,
$\rho \propto \varpi^{-2}$ and wind terminal velocity $\sim 2\Omega_0 R_X$
This stratification produces a dense jetlike structure visible in forbidden lines at the jet axis. The wide angle wind can be observed as large velocity widths at the base of the flow in position velocity diagrams **
Heating & cooling
Shang + 2010
wide-angle wind
Shang, Shu & Glassgold 1998
streamlines
Shu + 1995
** J. Najita, E. Ostriker, H. Shang, Glassgold, W.-C. Liu, C.-F. Liu
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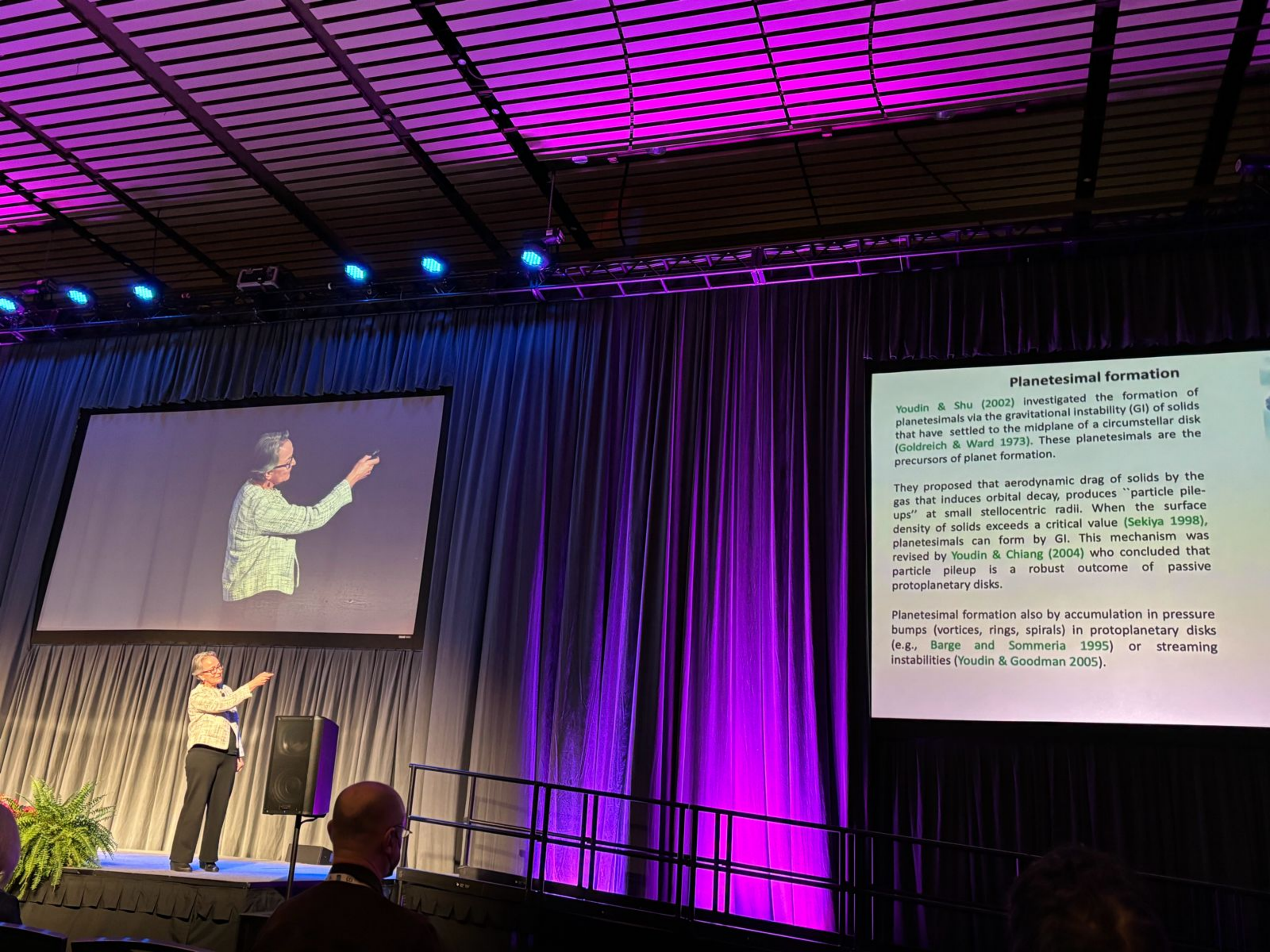
Planetesimal formation
Youdin & Shu (2002) investigated the formation of planetesimals via the gravitational instability (GI) of solids that have settled to the midplane of a circumstellar disk (Goldreich & Ward 1973). These planetesimals are the precursors of planet formation.
They proposed that aerodynamic drag of solids by the gas that induces orbital decay, produces ``particle pile-ups'' at small stellocentric radii. When the surface density of solids exceeds a critical value (Sekiya 1998), planetesimals can form by GI. This mechanism was revised by Youdin & Chiang (2004) who concluded that particle pileup is a robust outcome of passive protoplanetary disks.
Planetesimal formation also by accumulation in pressure bumps (vortices, rings, spirals) in protoplanetary disks (e.g., Barge and Sommeria 1995) or streaming instabilities (Youdin & Goodman 2005).


Thank you!
Tahoe meeting 2003