Circumstellar disk modeling with POLARIS

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Projet P2IO JWST

Modeling of circumstellar disks

Motivation

Modeling of circumstellar disks

- Provide predictions for observations

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- Derive constraints from existing observations

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Radiative transfer code

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- Full wavelength coverage (scattering + thermal)

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Radiative transfer code

- Versatile 3D approximation of the disk
- Dust grain heating (equilibrium + stochastic)
- Full wavelength coverage (scattering + thermal)
- Optical properties of various dust compositions

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  - Missing some key features

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- POLARIS (Reissl et al. 2016; Brauer et al. 2017)
  - Open source, own development
  - Missing some key features

$\Rightarrow$ Use POLARIS and include missing features

POLARIS

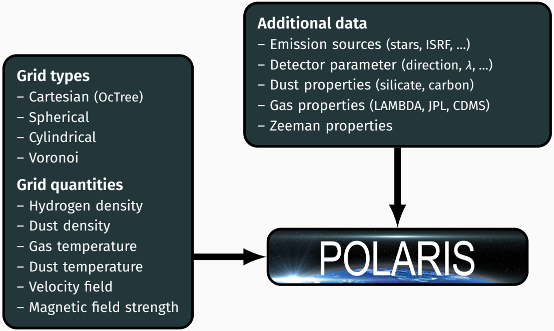
Grid types

- Cartesian (OcTree)
- Spherical
- Cylindrical
- Voronoi

Grid quantities

- Hydrogen density
- Dust density
- Gas temperature
- Dust temperature
- Velocity field
- Magnetic field strength

→ POLARIS



Additional data
– Emission sources (stars, ISRF, ...)
– Detector parameter (direction, λ, ...)
– Dust properties (silicate, carbon)
– Gas properties (LAMBDA, JPL, CDMS)
– Zeeman properties
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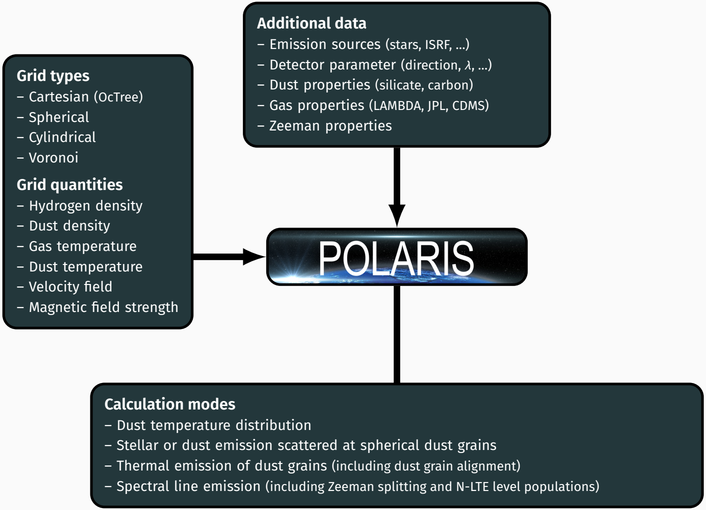
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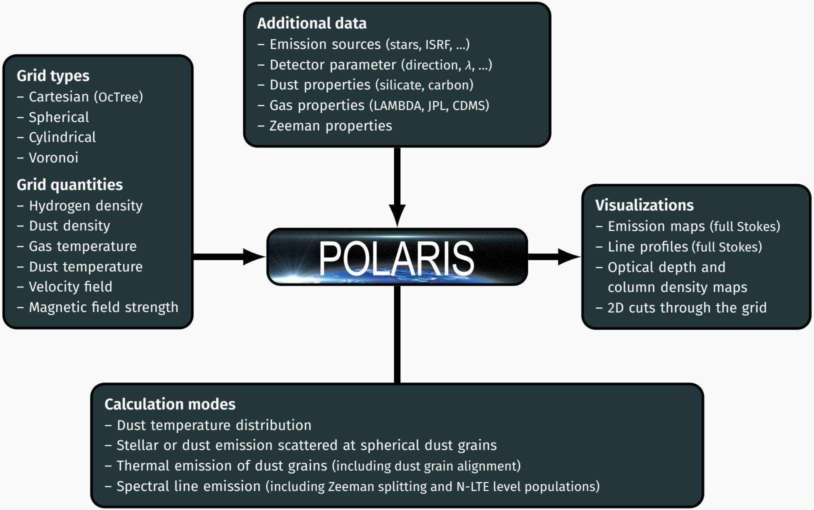
POLARIS
Calculation modes
– Dust temperature distribution
– Stellar or dust emission scattered at spherical dust grains
– Thermal emission of dust grains (including dust grain alignment)
– Spectral line emission (including Zeeman splitting and N-LTE level populations)



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Visualizations
– Emission maps (full Stokes)
– Line profiles (full Stokes)
– Optical depth and
column density maps
– 2D cuts through the grid
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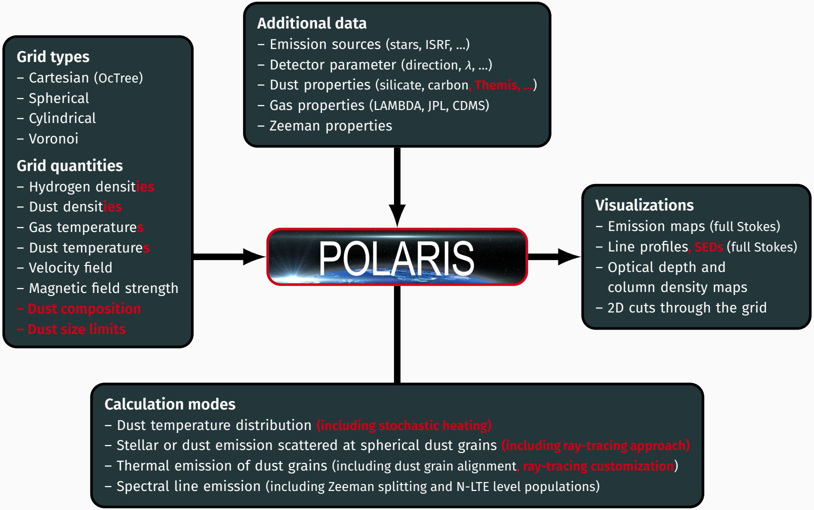
Additional data
– Emission sources (stars, ISRF, ...)
– Detector parameter (direction, λ, ...)
– Dust properties (silicate, carbon, Themis, ...)
– Gas properties (LAMBDA, JPL, CDMS)
– Zeeman properties
Grid types
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Grid quantities
– Hydrogen densities
– Dust densities
– Gas temperatures
– Dust temperatures
– Velocity field
– Magnetic field strength
– Dust composition
– Dust size limits
POLARIS
Visualizations
– Emission maps (full Stokes)
– Line profiles, SEDs (full Stokes)
– Optical depth and column density maps
– 2D cuts through the grid
Calculation modes
– Dust temperature distribution (including stochastic heating)
– Stellar or dust emission scattered at spherical dust grains (including ray-tracing approach)
– Thermal emission of dust grains (including dust grain alignment, ray-tracing customization)
– Spectral line emission (including Zeeman splitting and N-LTE level populations)

Dust grain options

Variation of dust properties

Dust grain options

- Single composition and size distribution

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- Mixture of several dust compositions

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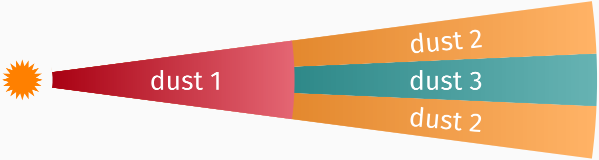
Use different dust per cell

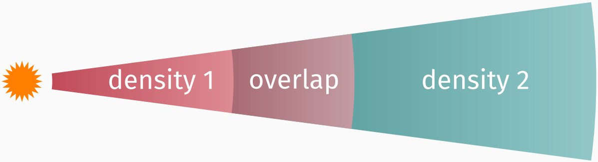


Variation of dust properties

Dust grain options

- Single composition and size distribution
- Mixture of several dust compositions

Use multiple density distributions



Variation of dust properties

Dust grain options

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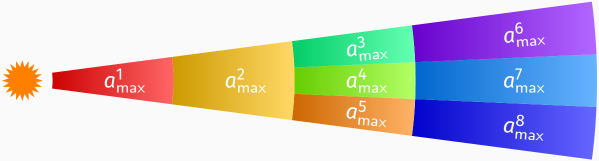
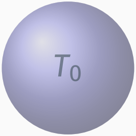
Use different size limits per cell



Stochastic heating

$a \lesssim 10\,\mathrm{nm}$, low $C(T)$



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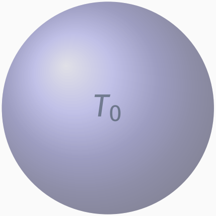

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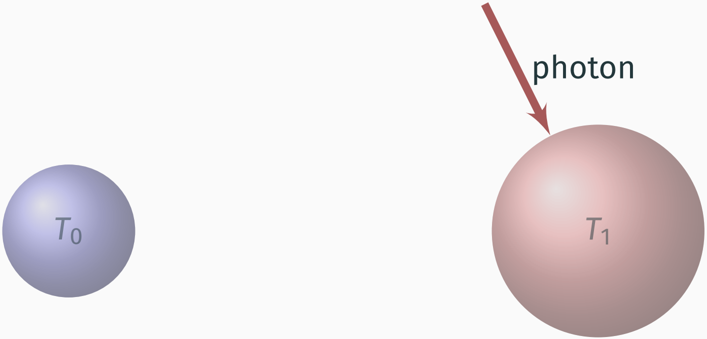

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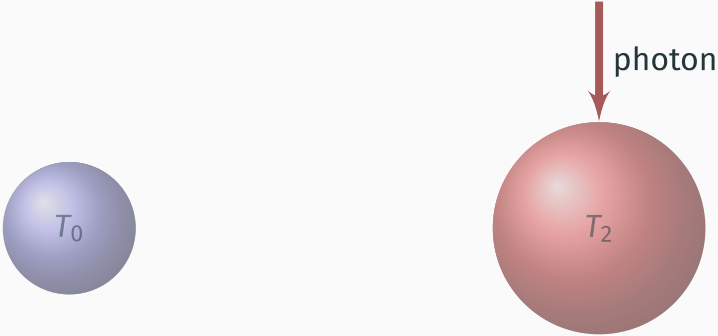

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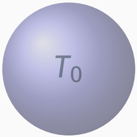

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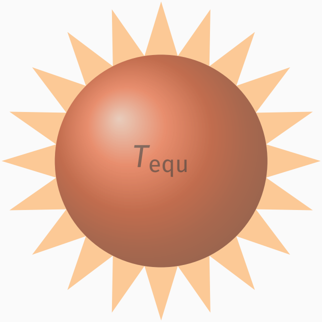

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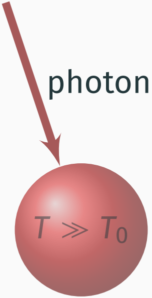

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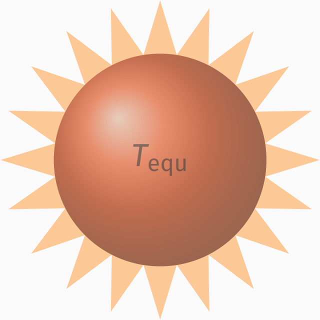

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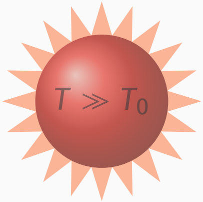

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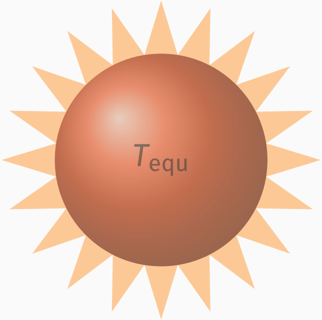

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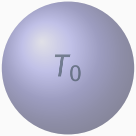

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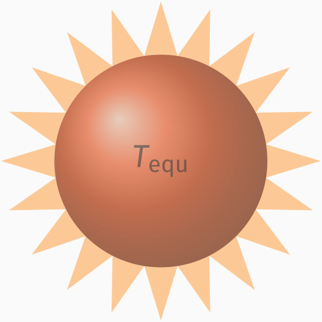

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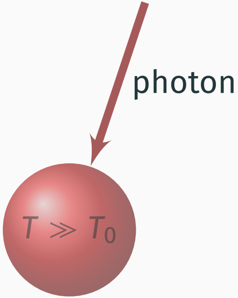

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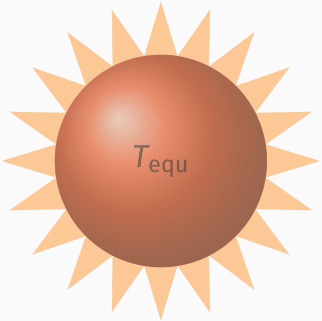

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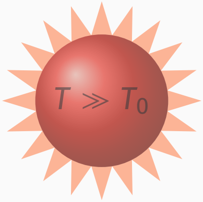

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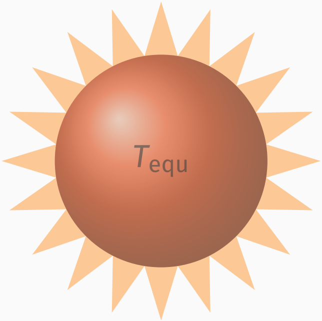

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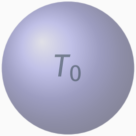

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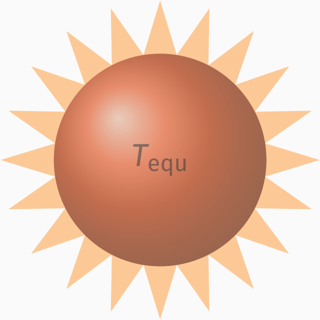

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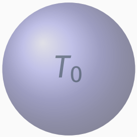

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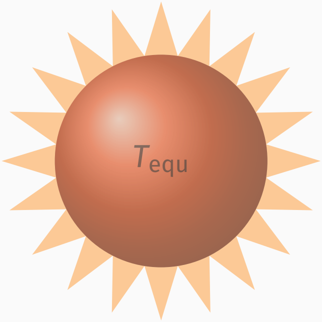
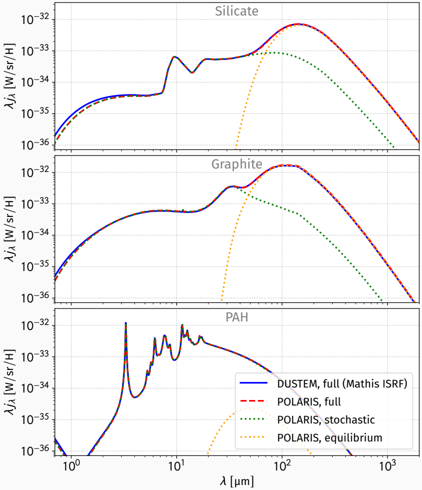


$\Rightarrow$ Probability distribution of temperatures instead of T_{equ}

Stochastic heating



Stochatically heated grains benchmark (CAMPS et al. 2015)

THEMIS

The **H**eterogeneous dust **E**volution **M**odel
for **I**nterstellar **S**olids

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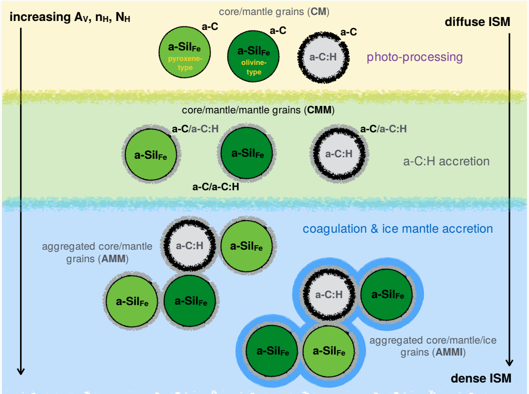

Overview of the Themis model (Jones et al. 2017)

THEMIS

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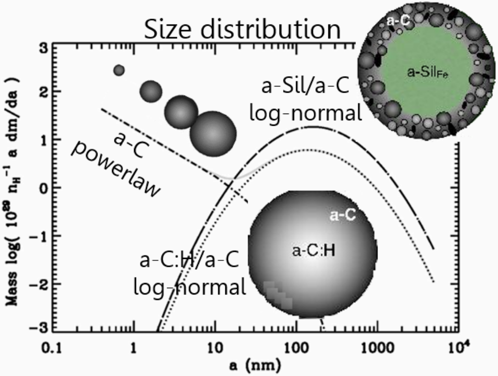

Size distribution (Jones et al. 2013)

Projects with POLARIS

Modeling GG Tau A

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- Constrain disk parameter and predict observations

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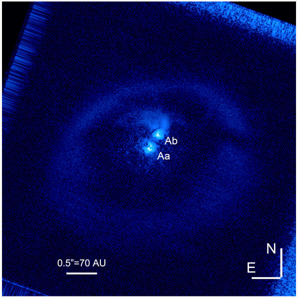

Polarized intensity
(Subaru/HiCIAO, Yang et al. 2017)

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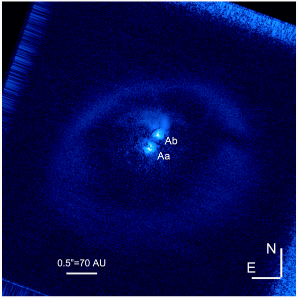

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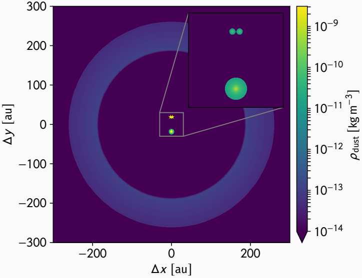

Dust density as a midplane cut

Modeling GG Tau A

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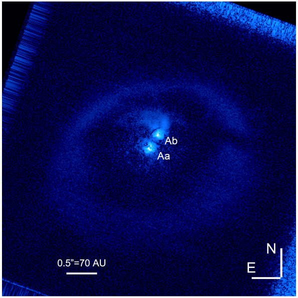

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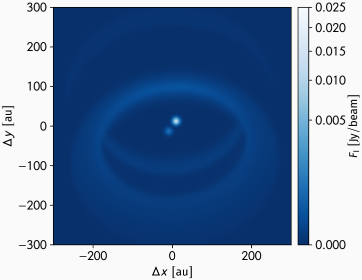

Simulated intensity (H-Band)

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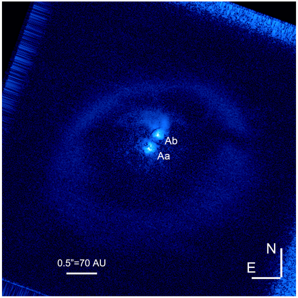

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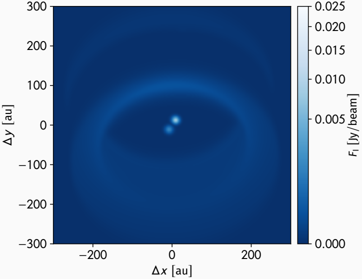

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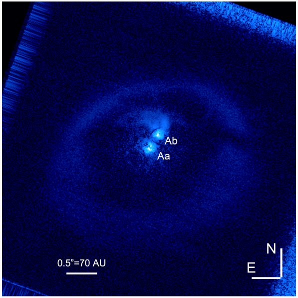

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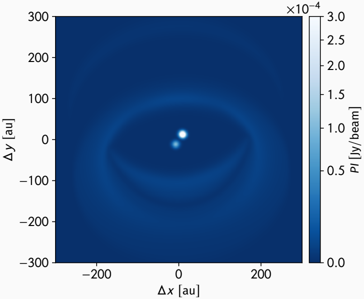

Simulated polarized intensity (H-Band)

Projects with POLARIS

Modeling GG Tau A

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Modeling circumstellar disks (with Thomas)

Projects with POLARIS

Modeling GG Tau A

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Modeling circumstellar disks (with Thomas)

- Aromatic and aliphatic infrared band emission

Projects with POLARIS

Modeling GG Tau A

- Constrain disk parameter and predict observations

Modeling circumstellar disks (with Thomas)

- Aromatic and aliphatic infrared band emission
- Spatial variations (including gaps and cavities)

Conclusions

Circumstellar disk modeling with POLARIS

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  ⇒ Numerous options for future projects

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Thank you for your attention