

Estimation of heat dissipation on a rotating rotor over superconducting magnet bearing

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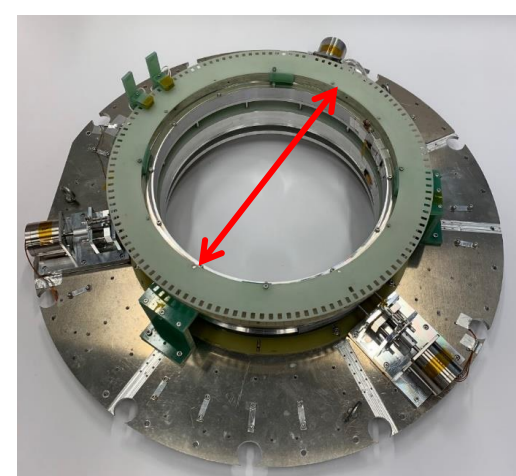
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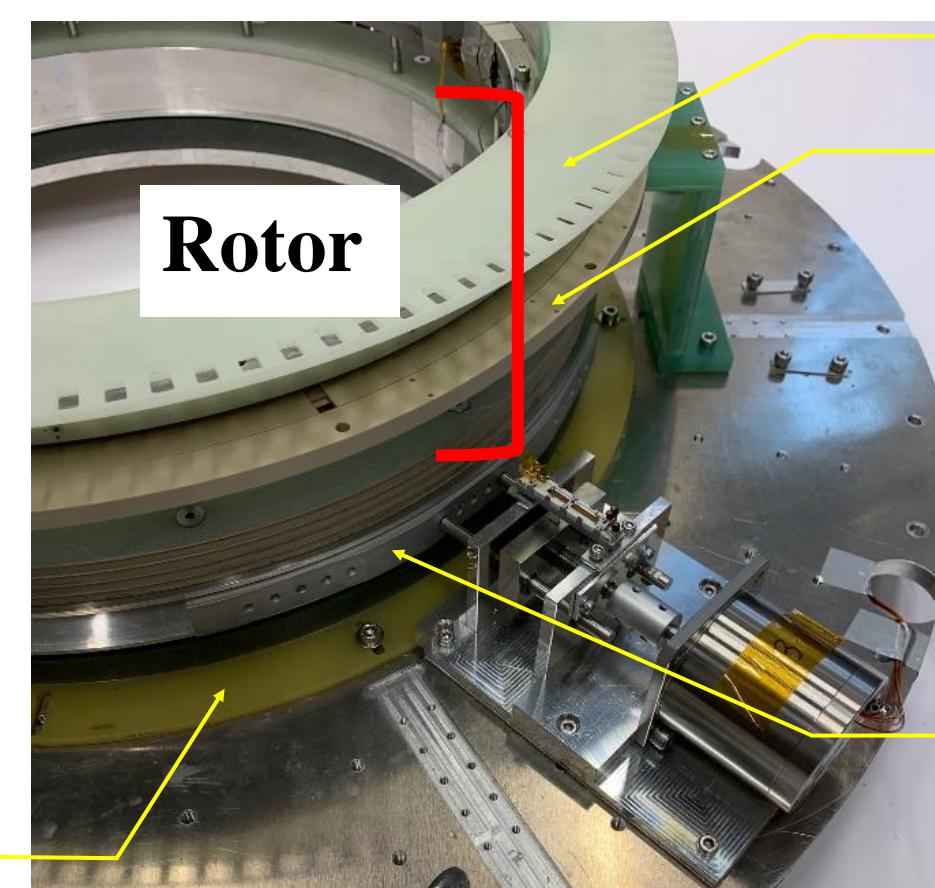
Key Instrument

Polarization modulator unit (PMU)



380 mm in Dia.

Superconducting magnet chassis



Encoder
Stator

Gripper

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Half Wave Plate

The half wave plate will be made of sapphire.

The rotating HWP modulates the CMB polarization signal.

The incoming signal to the HWP is upconverted in frequency far above the low frequency detector noise (1/f noise).

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Issues & Questions

Issues

Even though the SMB is a contactless bearing without any heat dissipation from mechanical frictions, there are still two potential losses:

Magnetic field inhomogeneousness & Eddy current

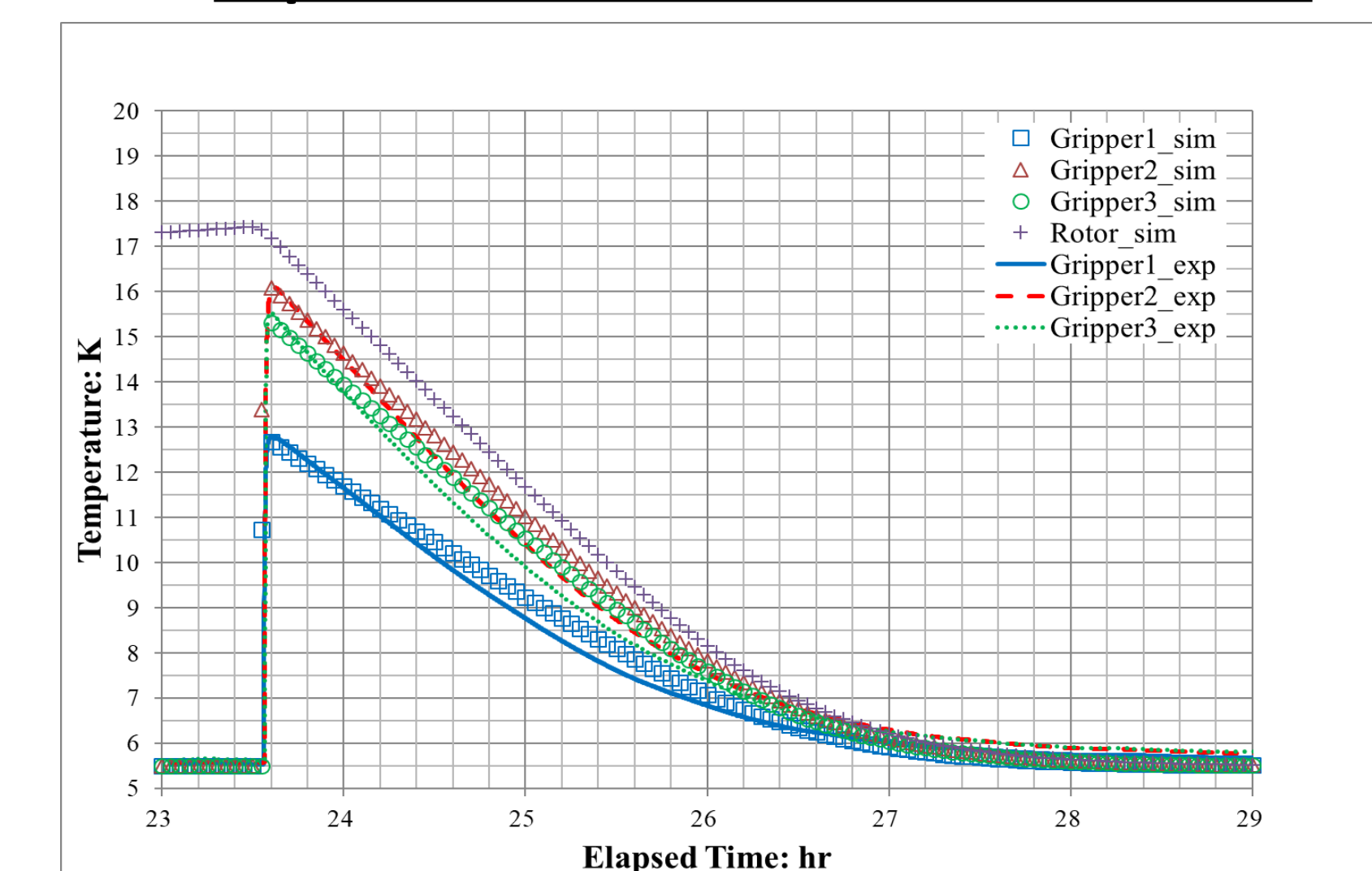
Questions

#1 **How much heat** is accumulated on the rotor when the rotor is rotating?

#2 **How much heat** is allowable to keep the HWP temperature below 20 K? (*Thermal design requirement*)

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Experimental and Simulation Results



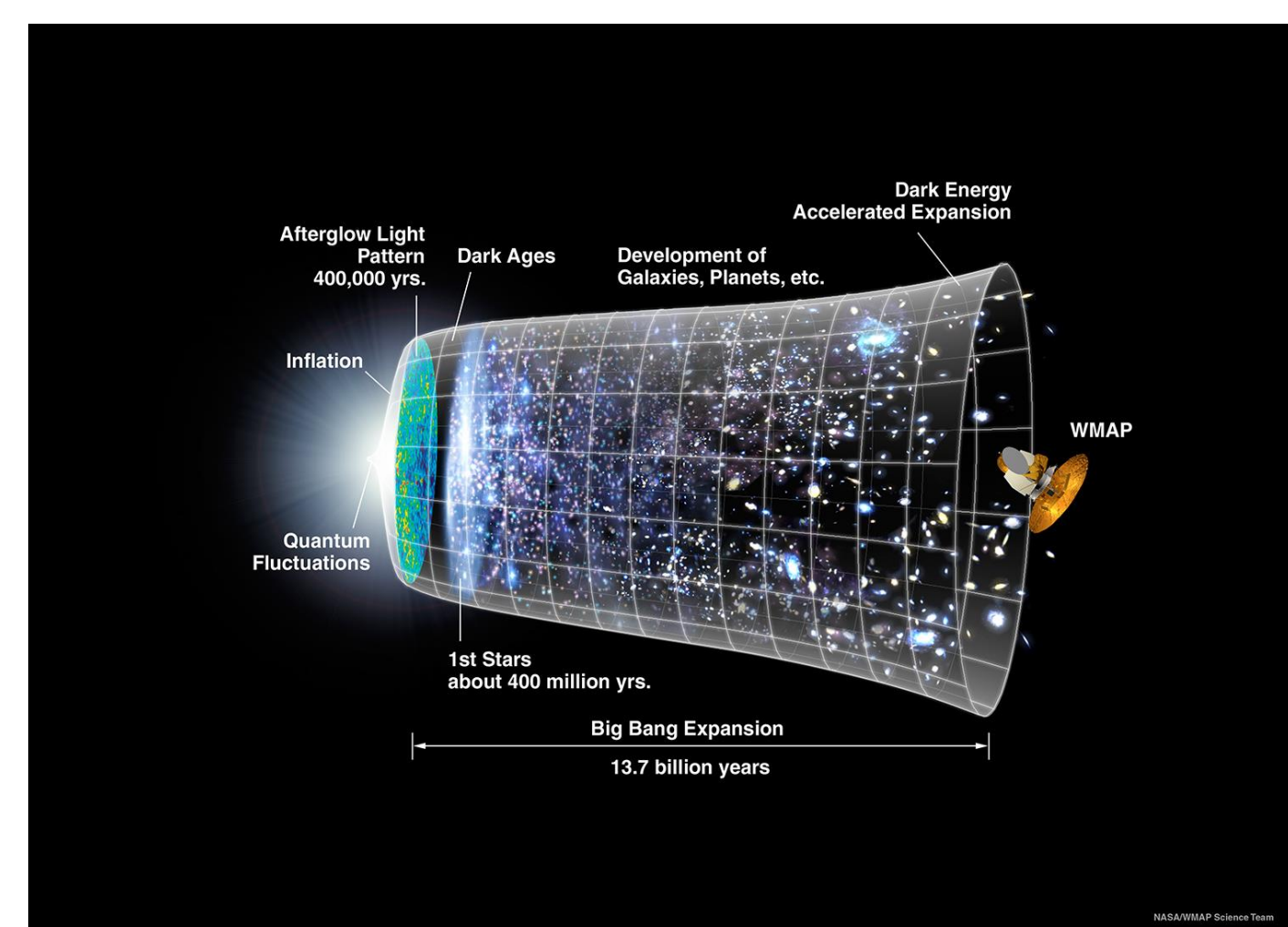
Fitting parameters:

- Heat dissipation on the rotor
- Thermal contact conductance of each gripper

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Introduction

- How was our universe born? -



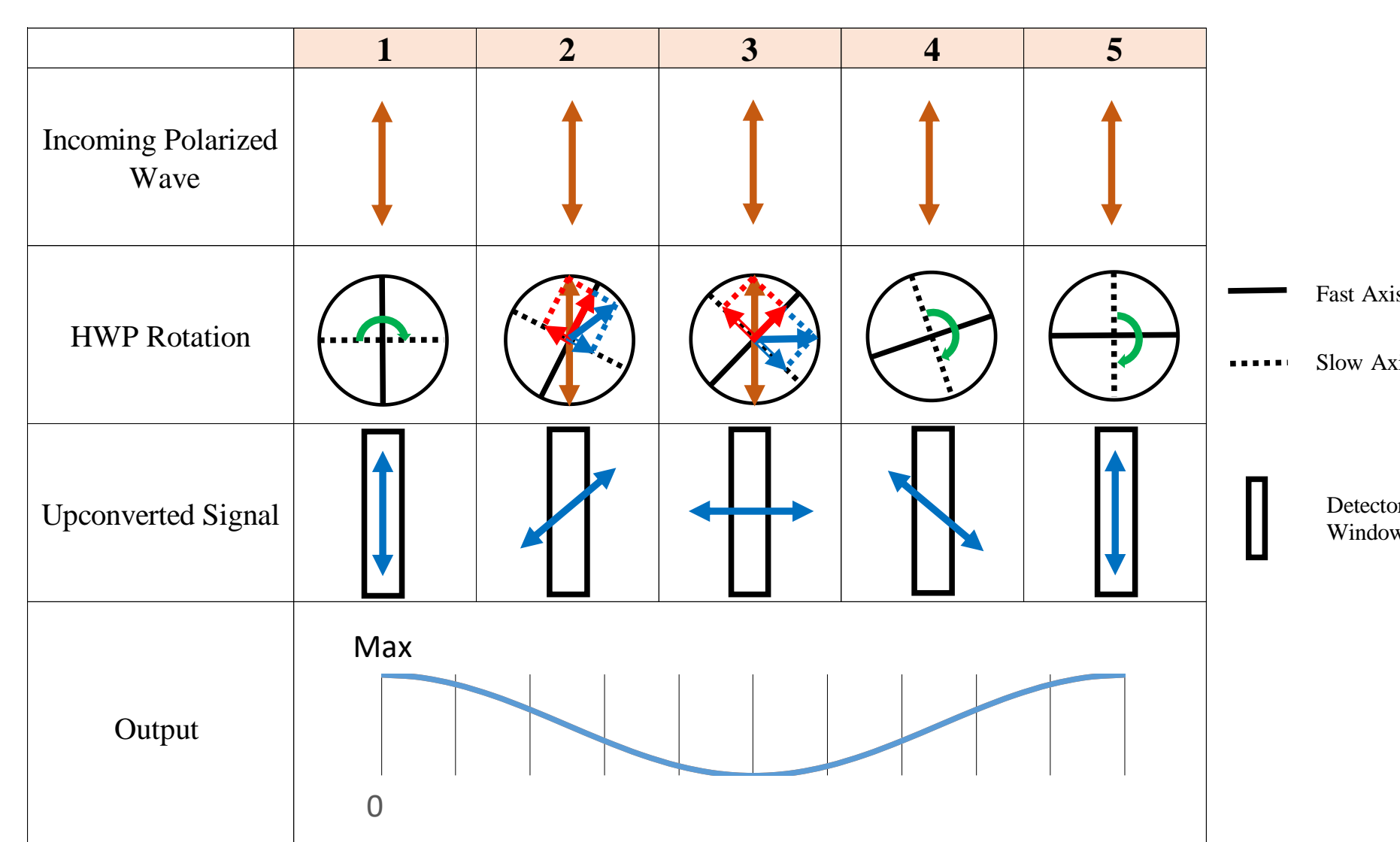
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Material List

Assembly name	Material	Remarks
Top rotor part	Aluminium 6061, SUS304	
Permanent magnet	SmCo	For rotation
Bottom rotor part	Aluminium 6061	
HWP	Sapphire	
Permanent magnet	SmCo	For levitation
Yoke for magnet	S45C	
Superconducting magnet bearing	YBCO	
SMB holder	G10	
Grippers	Aluminium 6061	
Gripper arms	SUS304	
4K cold plate	Aluminium 6061	

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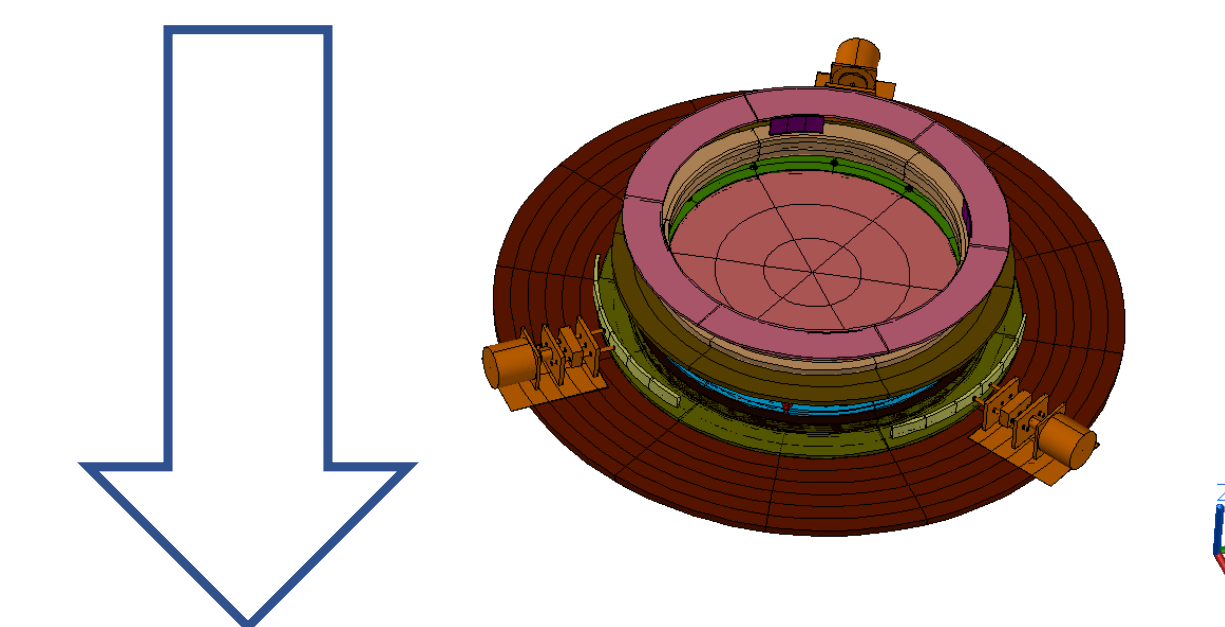
- Rotating HWP is modulating signal -



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- How to answer the questions? -

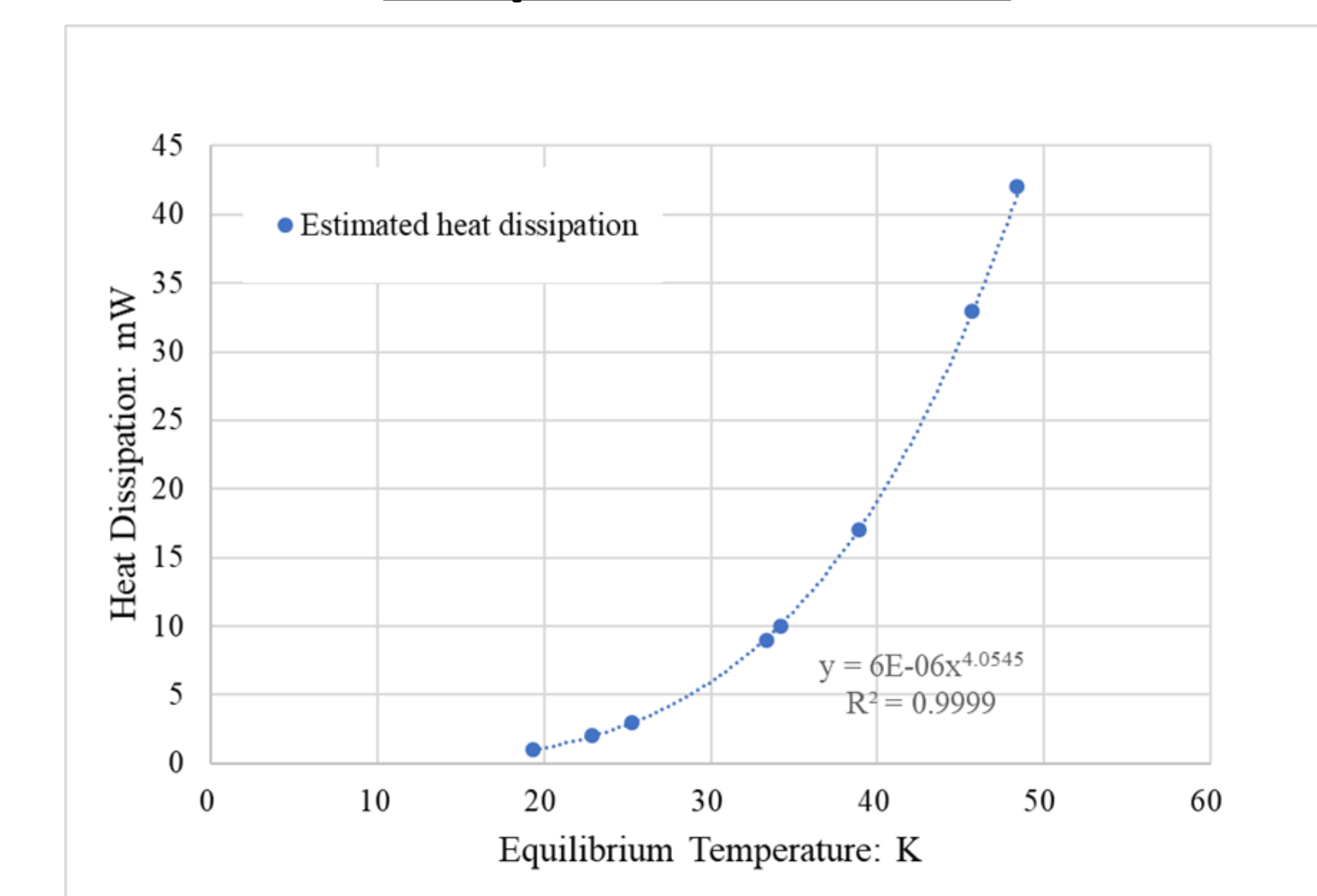
- ✓ The heat dissipation on the rotor is not measurable !
- ✓ The rotor temperature is not measurable !
- ✓ **Only the temperature on each gripper are measurable !**



Ans. Thermal simulation with experimental data

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Estimated Heat Dissipation to Equilibrium Temperature of HWP



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- Find the B-mode in the sky ! -

The theory of **Cosmic inflation**: which determines the model of how our universe was born.

B-mode: Gravitational waves generated by the cosmic inflation.

It is hidden in the cosmic microwave background.

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Rotor

To hold permanent magnet & half wave plate

Encoder

To monitor the rotor position

Stator

Driving mechanism to start, rotate and stop the rotor

Superconducting magnet bearing

To levitate the rotor

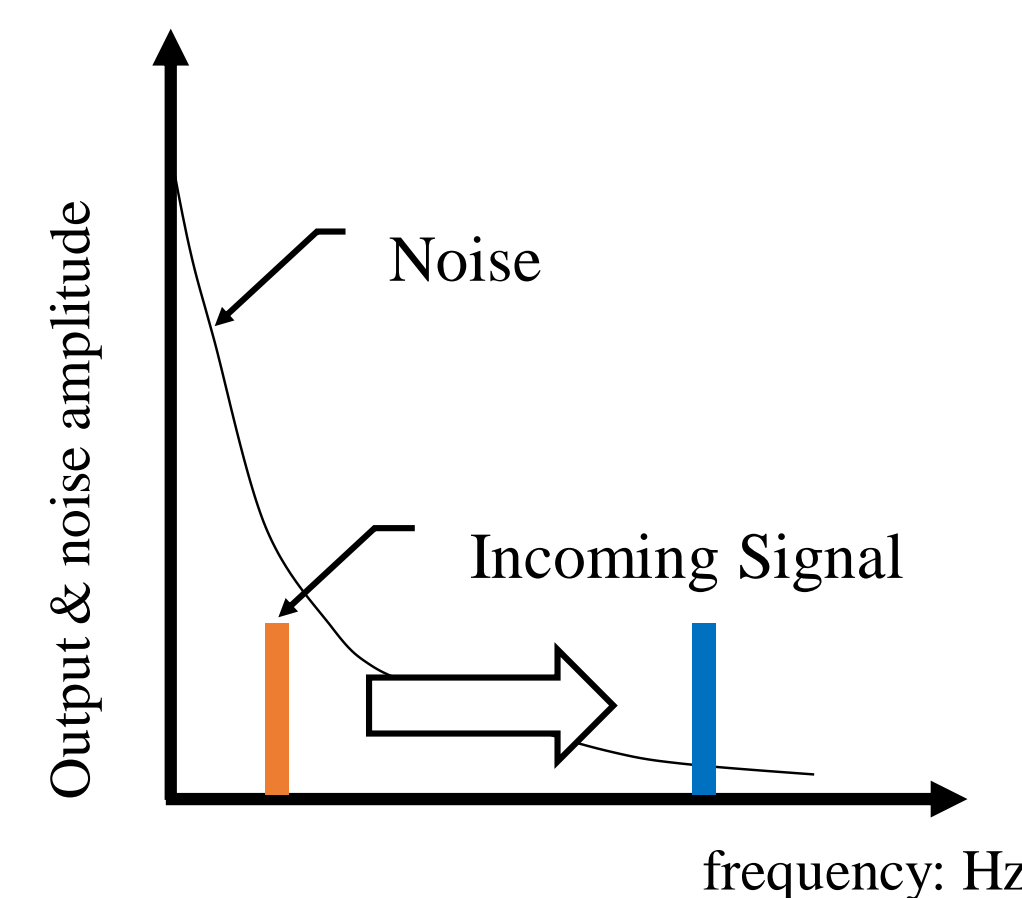
Grippers

To grab the rotor to re-cool and to hold it at launching

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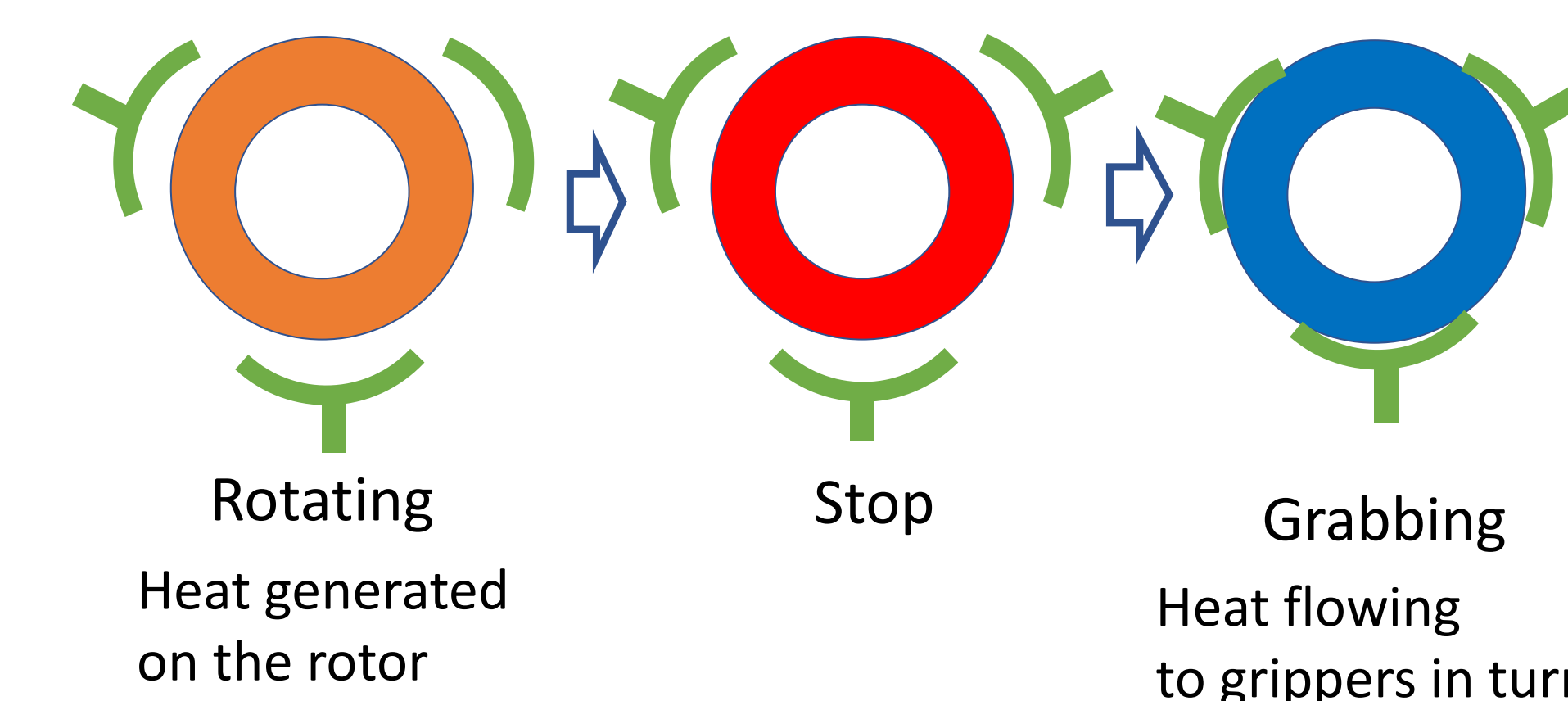
The incoming signal is upconverted in frequency out of the range of noise.

$$f_{up} = f_0 * 4$$



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- Experimental procedure to obtain gripper temperatures after the rotor stops -



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Conclusion

Using a thermal model along with the experimental data,

- ✓ The heat dissipation on the current rotor is estimated to be about 10 mW.
- ✓ The heat dissipation must be reduced to be 1 mW.

Measures to reduce the heat dissipation:

- To suppress the fluctuation in magnetic field on the rotor.
- To use a non-metallic material as much as possible.

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