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Micro-Newton scale variable thrust control technique and its noise problem for drag-free satellite platforms: a review

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Core Issue

High-precision detection

- space gravitational wave detection
- high-precision earth gravity field measurement
- reference frame drag effect measurement

requires

Satellite platform



drag-free control

key challenge

Thrust noise

key noise factors

- cross-basin flow problem
- control problem
- system instability and multiple-coupled problem

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Cross-basin Flow Problem

- **The thrust noise will generate from the flow fluctuation's boundary layer sensitivity and flow stability problems.**

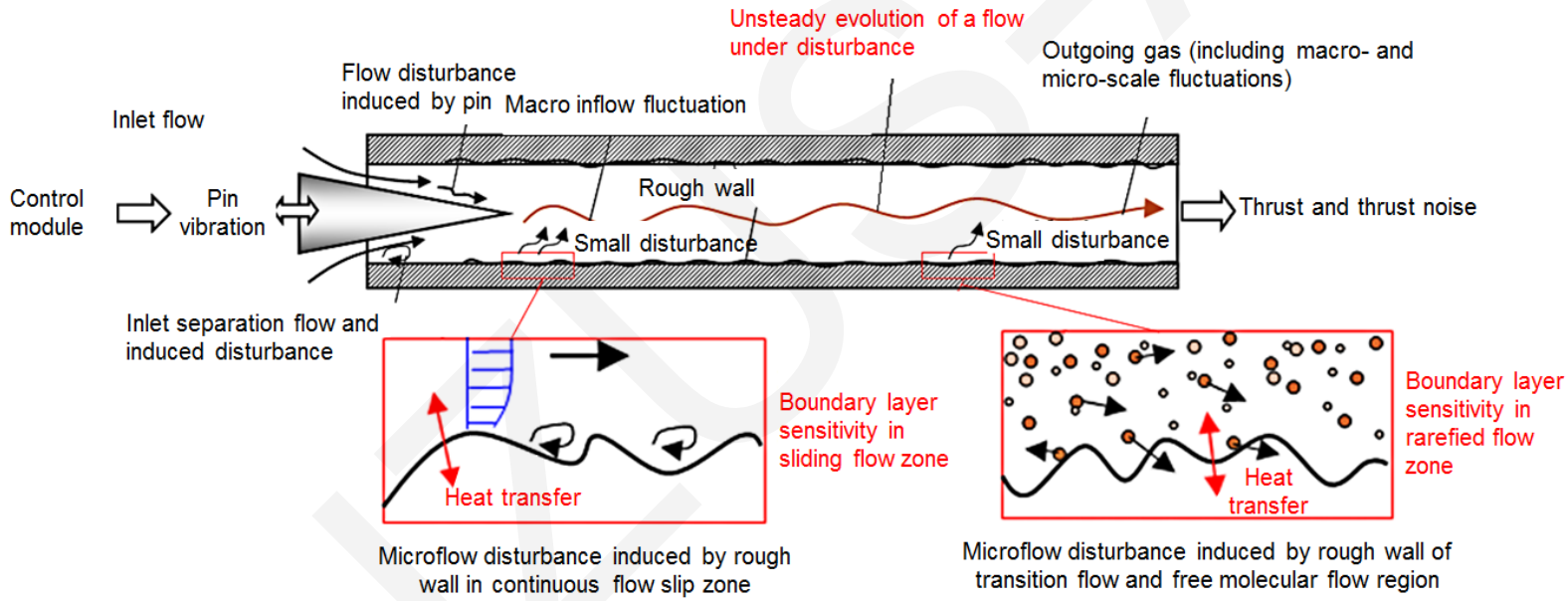

Fig. 1 Mechanism of cross-basin flow fluctuation and thrust noise in a micro nozzle

Control Problem

- The commonly used PID solution falls short of the target for drag-free control

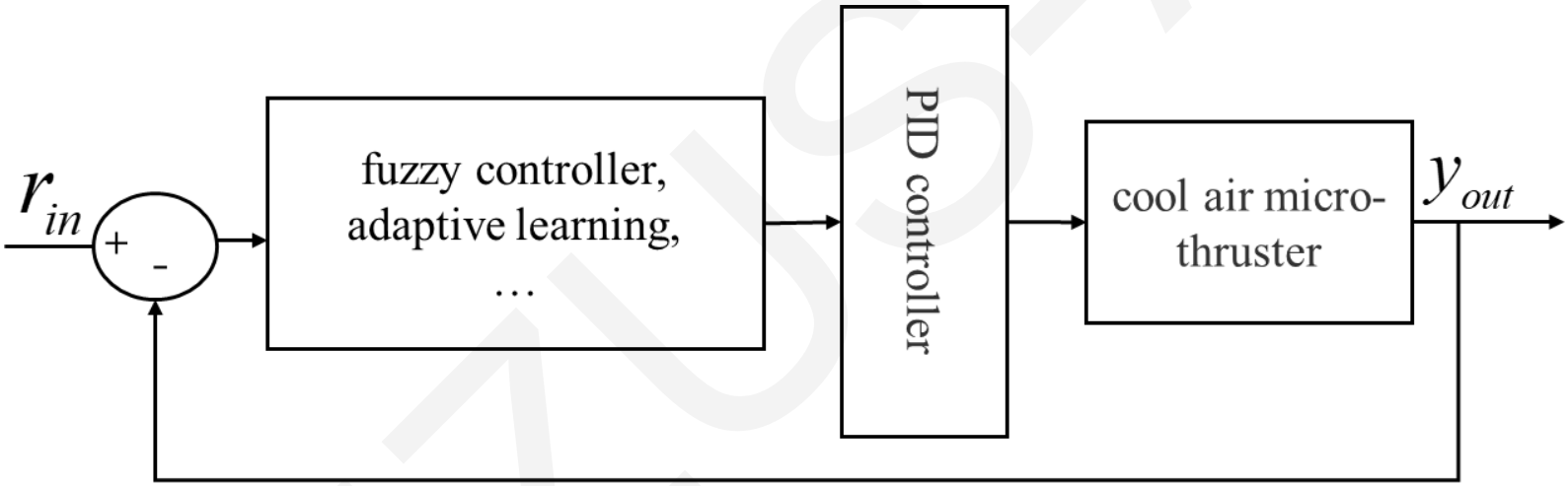

Fig. 2 Example of control methods in MVTC: (a) block diagram of variable universe fuzzy PID controller, where r_{in} is the input of system and y_{out} is the output of system.

System Instability and Multiple-coupled Problem

- In real engineering, the three items: the drive actuator, measurement feedback, and the cross-basin flow environment, are coupled together.

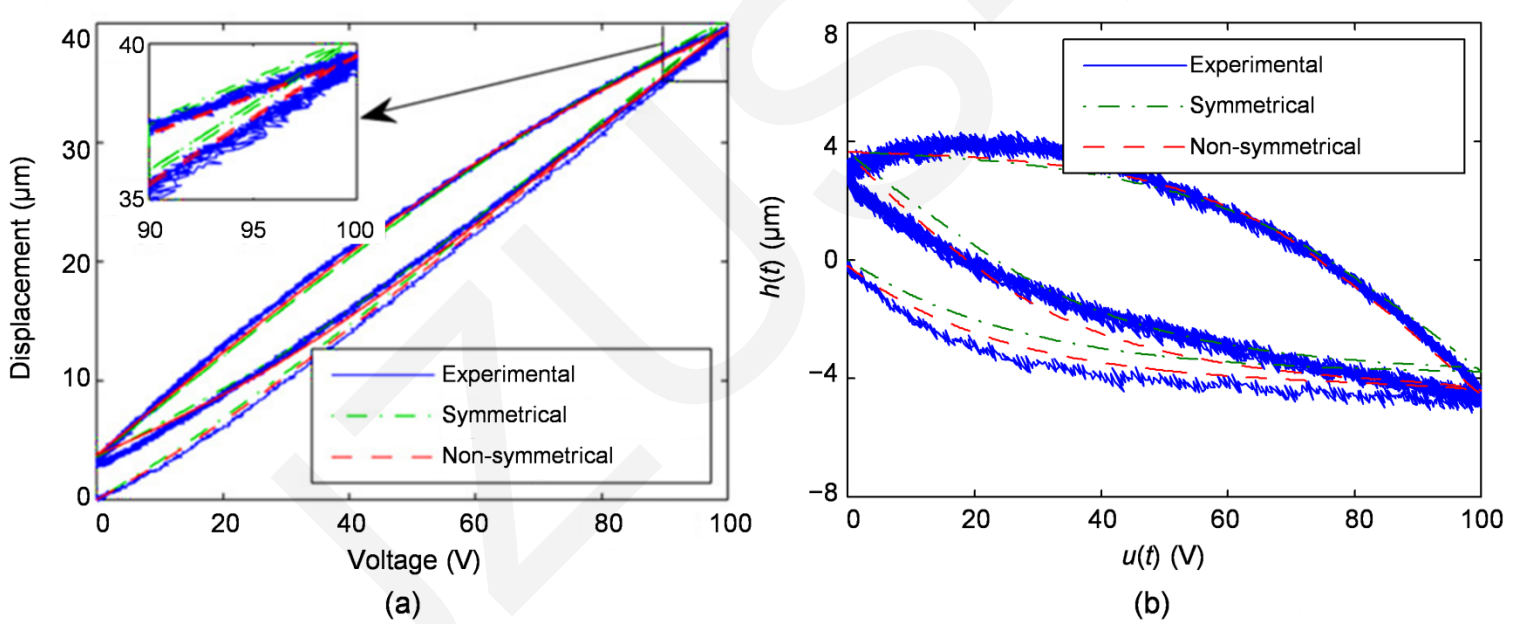

Fig. 3 Hysteresis simulation and linearization of piezoelectric ceramic actuators based on Bouc-Wen hysteresis opera-tors: (a) hysteretic curves; (b) hysteresis component. Reprinted from (Zhu and Wang, 2012), Copyright 2012, with permission from Elsevier

Conclusions

- Based on existing research, there is still a lack of in-depth consideration of ‘complex cross-basin flow,’ ‘space working environments,’ ‘thrust noise mechanism,’ and ‘active suppressing methods,’ which could bring a further improvement of the noise problem in the future.



Drag-free Control