MEDICAL UNIVERCITY OF PLOVDIV
FACULTY OF PHARMACY
DEPARTMENT OF MEDICAL PHYSICS AND BIOPHYSICS

CASTRA - BULGARIA

VIKTOR VLADIMIROV YOTOV, PH.D.

LIVING IN SPACE: RPM SIMULATED MICROGRAVITY STUDIES AT MEDICAL UNIVERSITY-PLOVDIV

59th Virtual UNISEC-Global Meeting, August 16, 2025; **Contact: viktor.yotov@mu-plovdiv.bg**

SPACE IS FOR QUESTING AND WONDERING, FOR EXPLORING UNANSWERED QUESTIONS ABOUT THE UNIVERSE AND OURSELVES

CARL SAGAN,
PALE BLUE DOT (1994)

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HOW MICROGRAVITY AFFECTS THE HUMAN HEALTH?

•Morphological changes in the heart(Summers et al, 2005);

•Changes in heart rate, blood vessel lumen, change in vascular smooth muscle contractility (Liu et al, 2021).

• Lack of sleep (Stoilova et al., 2003; Petit et al., 2019);
• Difficulties in communication (Basner et al, 2014);
•Agression in animal models;
•Difficulty performing various tasks and abstract thinking (Grabherr, 2010);

Changes in muscle tone

▪Decreased bone density (Willey et al, 2011) and premature osteoporotic changes (Cazzaniga et al, 2016)

▪Increase in the height of astronauts upon return from long missions;

• Changes in smooth muscle contractions (Pei et al, 1997);
• Changes in mucosal barrier function (Atiashkin and Bykov, 2012).
• Reduced energy intake and weight loss (Smith et al, 2004);

HOW TO TEST MICROGRAVITY EFFECTS ON LIVING ORGANISMS?

ANALOGIES TO MICROGRAVITY

SPACE EXPERIMETNS

- **REAL MICROGRAVITY ($\sim 10^{-3}$ - $< 10^{-6}$ g);**
- Restricted access to experiment conditions during testing;
- Demanding big teams to launch and operate a space mission;

SIMULATING MICROGRAVITY EFFECTS (LONG-TERM)

- Hindlimb unloading – animal use;
- Random positioning machine - **RPM**;
- Head tilt bed rest – human tests;
- Dry immersion – human tests;

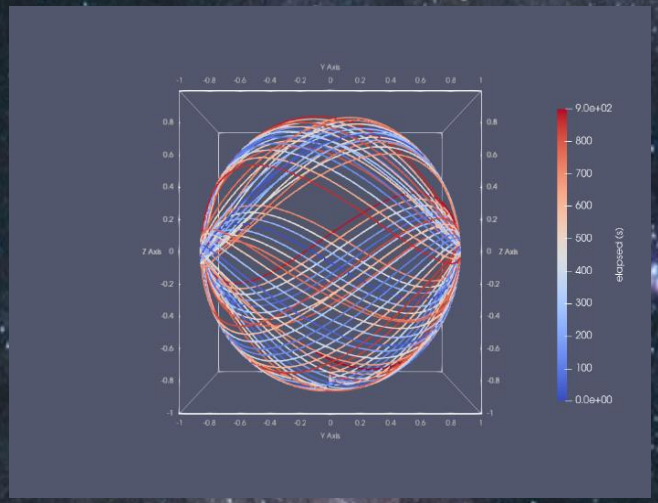
RECREATION OF MICROGRAVITY EFFECTS (SHORT-TERM)

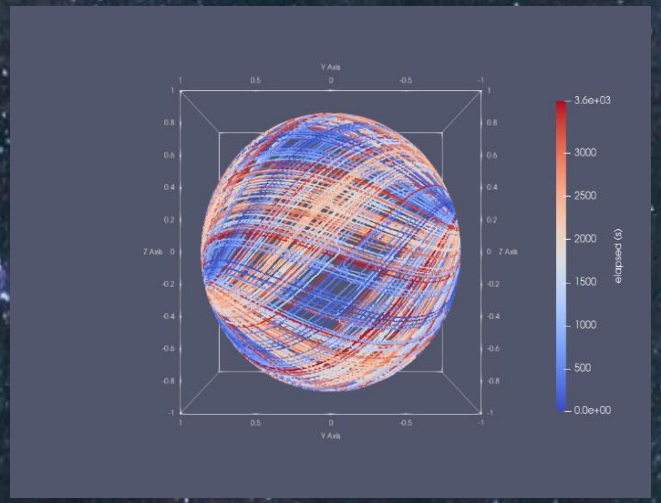
- Parabolic flights;
- Sounding rockets;
- Drop towers;

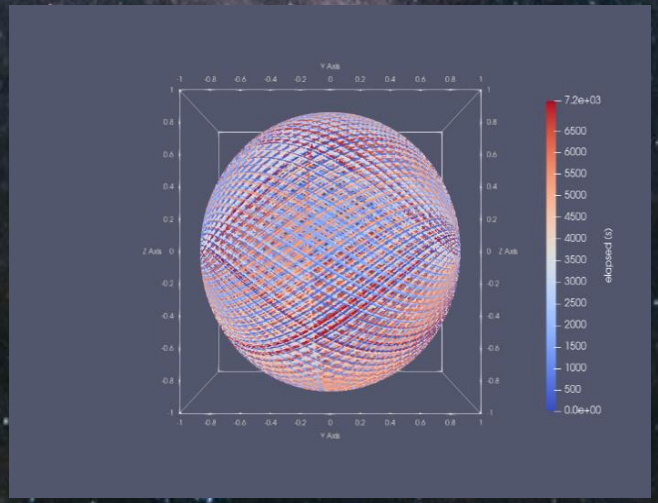
HOW RPM WORKS?

$$G_{mean,t} = \sqrt{{G_{x,t}}^2 + {G_{y,t}}^2 + {G_{z,t}}^2} \approx 10^{-3}\ to\ 10^{-6} g,$$

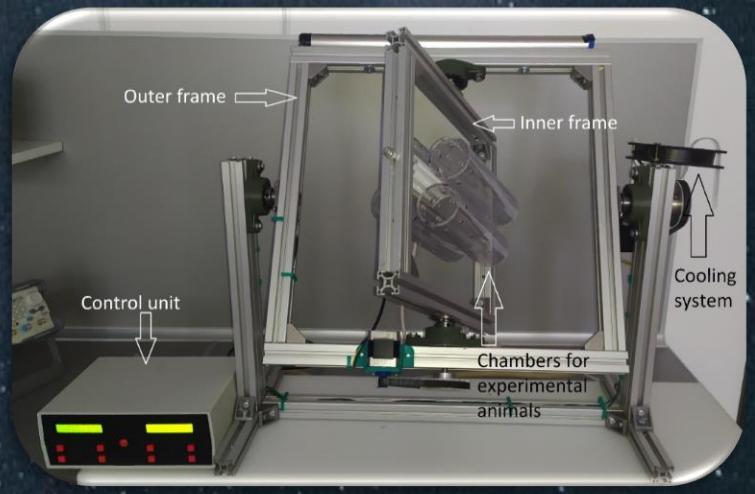
$$g = 9.81\ m/s^2$$







Distribution of the gravitational vector on virtual sphere. The distribution shows how well the gravity is "removed".

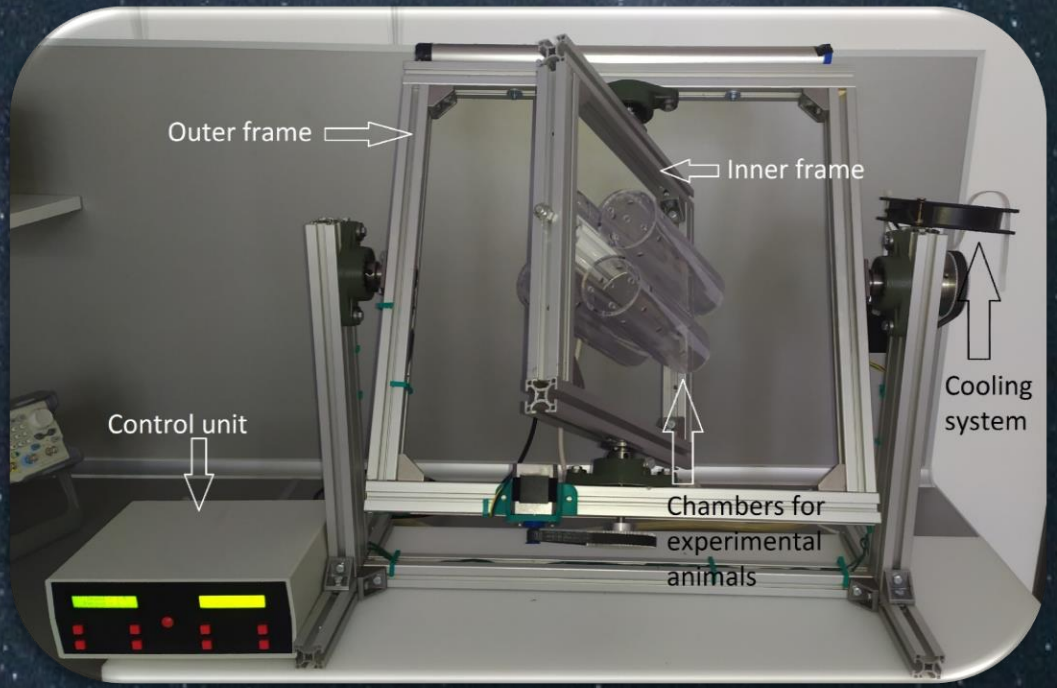


More information check the following papers:

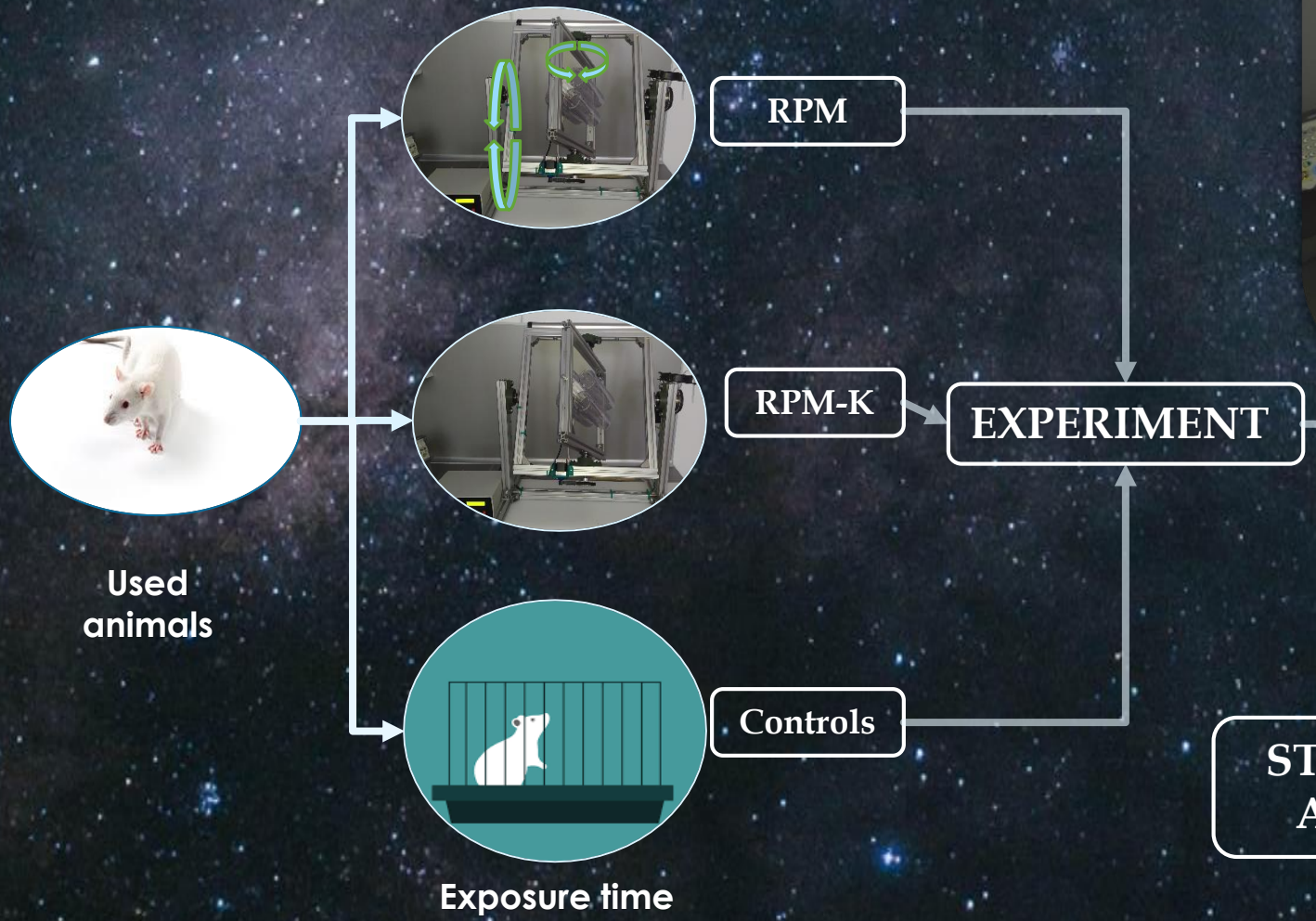
- Yotov, V.V.; Marovska, J.; Turiyski, V.; Ivanov, S.I. A new random positioning machine modification applied for microgravity simulation in laboratory experiments with rats. Inventions 2022, 7, 85;
- Kim, T.Y. Theoretical study on microgravity and hypogravity simulated by random positioning machine. Acta Astronaut. 2020, 177, 684–696.;
- van Loon, J.J.W.A. Some history and use of the random positioning machine, RPM, in gravity related research. Adv. Space Res. 2007, 39, 1161–1165.

 Contact: viktor.yotov@mu-plovdiv.bg

RAT-RPM MODEL USED IN MEDICAL UNIVERSITY OF PLOVDIV



RPM used in Medical University of Plovdiv.



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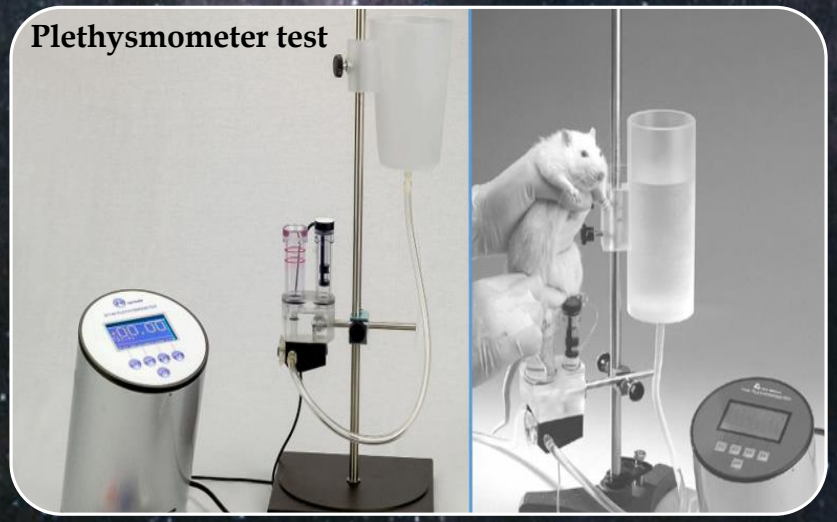
RESULTS FROM THE RAT-RPM MODEL

Cross-maze test

Plethysmometer test



- Rats subjected to RPM-simulated microgravity had significantly lower body mass compared to the control animals.
- At the end of the test period, rats from the RPM group had lower levels of psychological stress compared to animals from the two control groups.
- The kinetics of the inflammatory response (induced with intraplantar injection) in RPM animals is delayed in the first hours and enhanced at 24 hours compared to controls.

More information check the following paper:

- Yotov, V.V.; Ardasheva, R.; Mihailova, A.; Doncheva, N.; Kostadinov, I.; Turiyski, V.; SIMULATED MICROGRAVITY AFFECTS CARRAGEENAN-INDUCED INFLAMMATION PROCESS IN RATS. Pharmacia (2023), 70(4): 1531-1538.

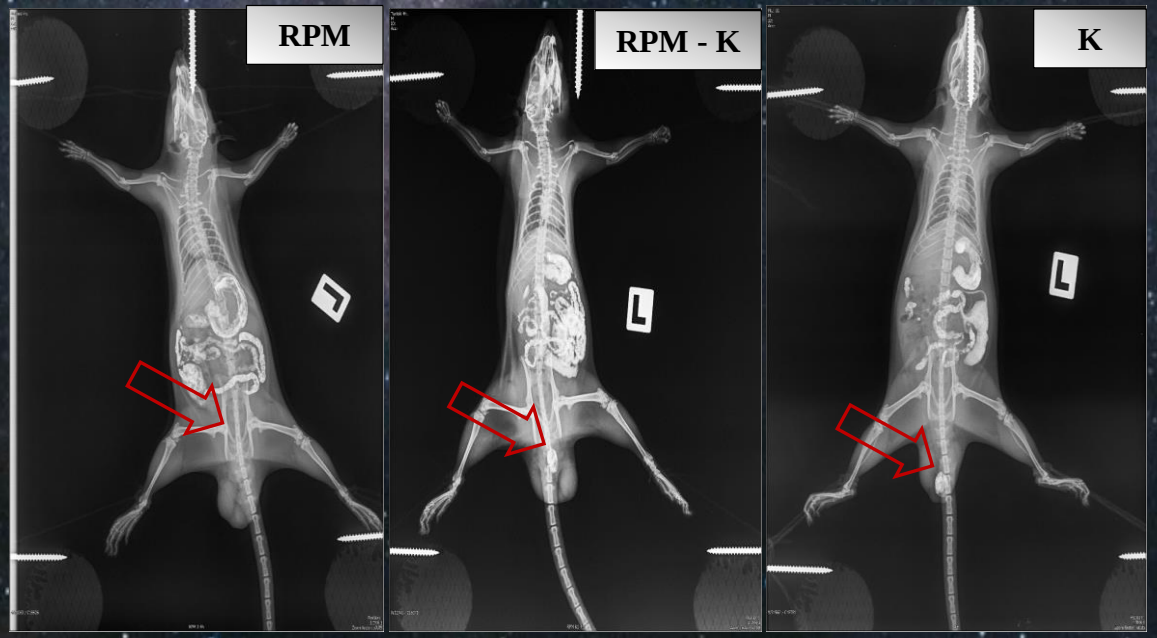
RESULTS FROM THE RAT-RPM MODEL

- RPM-Simulated microgravity induces increased acetylcholinesterase activity and a decrease in some oxidative stress biomarkers in rat hippocampus.
- Increased number of α7-nACh receptors in the hippocampus of rats subjected to RPM – simulated microgravity compared to the respected controls.
- A deterioration in long-term memory functions was found in RPM-subjected rats compared to the controls, along with a pronounced tendency towards more successful learning.

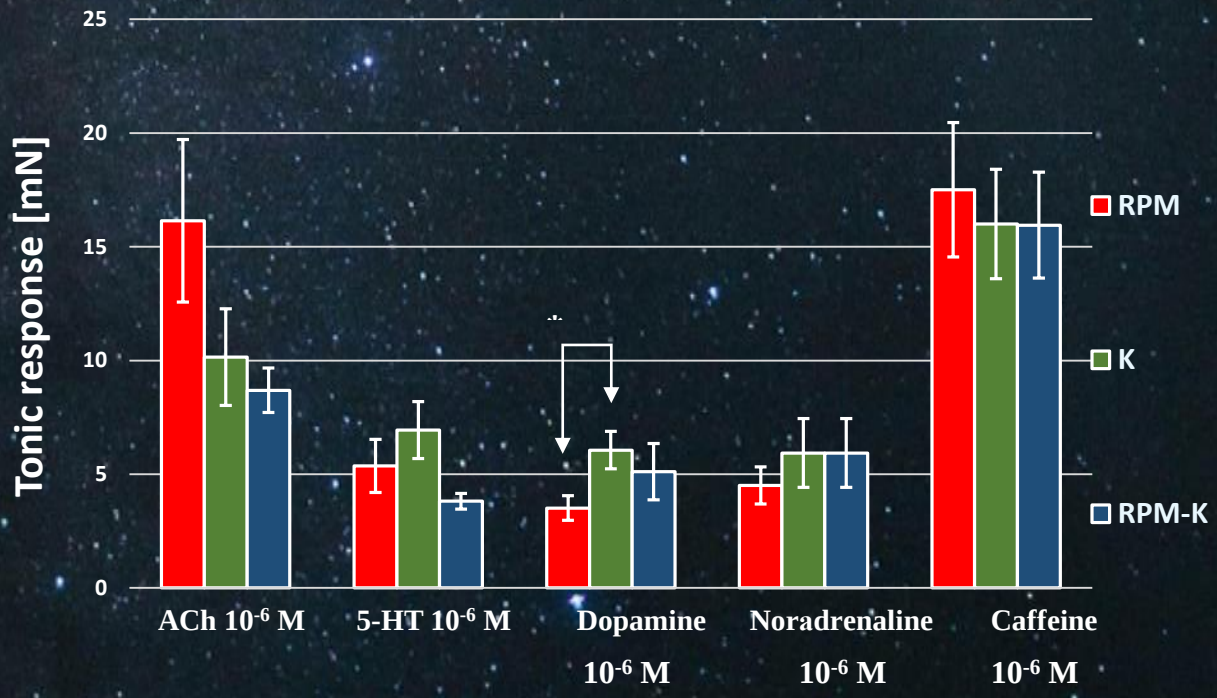

Shuttle-box (Ugo Basile, Italy)

RESULTS FROM THE RAT-RPM MODEL

- The contractile reactivity of gastric smooth muscle preparations isolated from RPM rats to ACh was increased compared to that of controls, and their reactivity to Dopamine was decreased.
- Simulated microgravity causes changes in the motility and evacuation function of the gastrointestinal tract, resulting in delayed evacuation of the upper levels of the tract.



4th hour of probing with $BaSO_4$



SUMMARY OF THE RPM-RAT MODEL

- Accuracy – some of the obtained results are already known for astronauts.
- Predictability – we can use the model to evaluate the future health problems, especially in long-term exposures to microgravity.
- Details of the physiological condition – the animal model gives the opportunity to find the mechanisms of a condition.
- Caution – extrapolation of results from a rat to human should be made with great caution.
- Main limitations – still have gravity; lack of ionizing radiation.

Contacts: Viktor Yotov, PhD
e-mail: viktor.yotov@mu-plovdiv.bg

59TH VIRTUAL UNISEC-GLOBAL MEETING, AUGUST 16, 2025