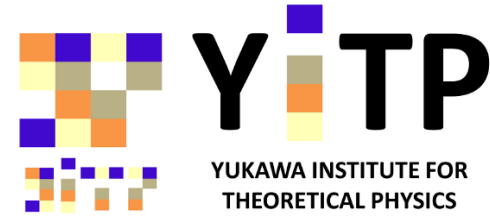# Kyozi Kawasaki:
# his physics and my personal recollection

## Hisao Hayakawa (YITP, Kyoto Univ.)

In Memorial Session (August 9th) of Statphys 28
August 7-11, 2023 at the University of Tokyo, Japan

# Self introduction

- It is my great honor to present Kyozi's memorial talk.

- I was Kyozi's student.

- However, I was not a good student, and thus I have only one joint proceeding paper with him.

  - This paper was not included in his publication list in Physica A, which celebrated his retirement in 1993.

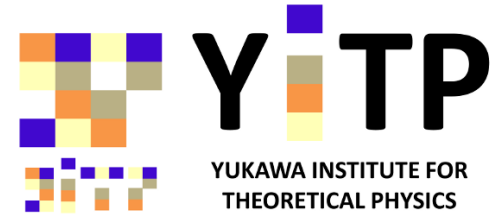YUKAWA INSTITUTE FOR
THEORETICAL PHYSICS
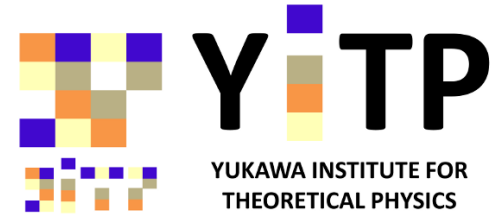
Butsuri 2000

From left to right: Ryogo Kubo, Natsuki Hashitume, Kazumasa Tomita &
Hazime Mori (Top) taken by Kyozi
Kyozi in 1964 in MIT (Bottom)

# His personal data

- Born in August 4th, 1930 at <span style="color:red">Otsu</span> in Shiga, Japan
- He moved to Nogata in Fukuoka, Kagoshima, Shizuoka.
- He entered Shizuoka junior high school, and moved to Imperial Japanese Army Childhood. Schools (Nagoya), Nirayama junior high school and graduated <span style="color:red">Kashima (Saga) junior high school</span>.
- He entered Saga high school, but this high school was closed during his stay.
- He entered and graduated <span style="color:red">Kyushu University</span>.

# From particle physics to statistical mechanics

M. Ozaki



- He majored in particle physics.

- His supervisor was <u>Masaharu Ozaki</u>.

- The supervisor caused an affair.

- All lab members and many faculty members in Kyushu University left.

- Kyozi's lab mate was <u>Ryogo Hirota</u> who changed the field and becomes well-known as his soliton theory.



R. Hirota

**Yi TP**
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Memory of Kyozi Kawasaki

# PhD work in Duke

- He got PhD in Duke at Durham, North Carolina.
  - He belonged to low temperature physics lab. The advisors were W. Fairbank (theoretician) & M. Buickingham (experimentalist).
  - He learned the importance of experiments but he admitted some mismatch between him and supervisors.
  - He could published some related paper after he went back to Japan.
  - Thesis title is "The Statistical Mechanics of Irreversible Processes" (1959).

# His work with Hazime Mori

- He became a PD of <span style="color:red">Hazime Mori</span>.
  - Mori is well known as advocator of Mori's projection method.
- Kyozi and Hazime analyzed the critical dynamics of Heisenberg chains based on Kubo formula, Matsubara's Green function and short-time decoupling.
- Kyozi was not satisfied by this crude approximation, although the papers were highly appreciated at that time.
- After that, he was an assistant of Nagoya University.
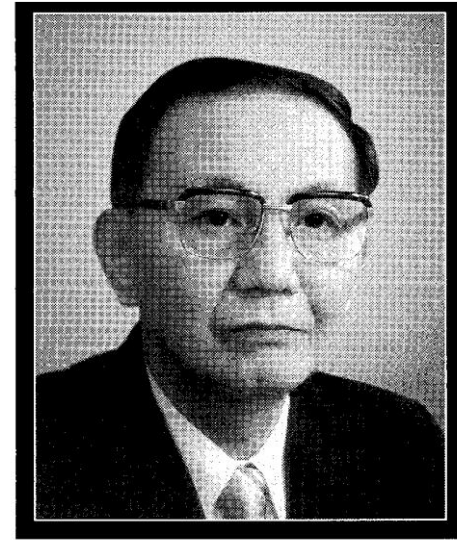
# Kyozi's second stay in US

- Kyozi decided to quit his job in Nagoya, and he joined MIT as a PD of Irvin Oppenheim in 1963.

- He stayed there until 1966.

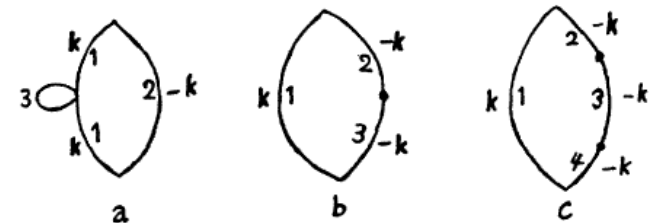- These 3 years were most fruitful for Kyozi's scientific activity.

# Kawasaki-Oppenheim (1965)

- He and Oppenheim analyzed the kinetic theory of gases with finite density.

- They found the violation of the virial expansion as

$$\eta = \begin{cases} \eta_0 + \eta_1 n + \eta_2' n^2 \log n & (d = 3) \\ \eta_0 + \eta_1' \log n & (d = 2) \end{cases}$$

(see KK and IO, Phys. Rev. **139**, A1763 (1965)).

# Kawasaki dynamics (1965)

- Kyozi is known as the proposer of <span style="color:red">Kawasaki dynamics</span>.

- He demonstrated the absence of dynamic singularity in the critical dynamics of "model B" (for diffusive conserved order parameter).

- See Kawasaki, Phys. Rev. **145**, 224, **148**, 375, **150**, 285 (1966).

- Lebowitz and his group call the model Kawasaki dynamics.

# Mode-coupling theory (MCT)



- MCT was proposed by Marshall Fixman in 1962, although he did not call his theory MCT.

  - He predicted the divergence of viscosity at the critical point due to coupling of some modes such as the entropy and velocity field.

  - No microscopic starting point
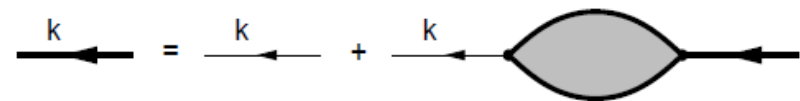
- Kyozi's MCT (1966-1970)
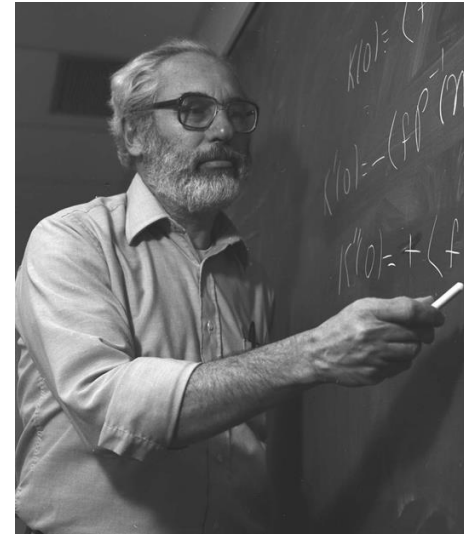
# Kyozi's MCT
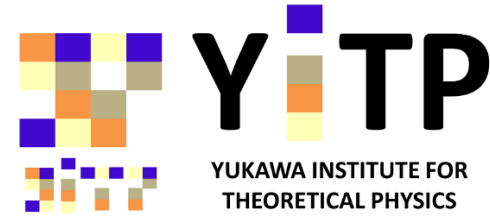
- Kyozi reformulated MCT with the aid of Kubo formula $L = \int_0^\infty dt < J(t)J(0) >$ .

- He expressed the current as

$$J = \sum_{jl} \mathcal{V}_{jl}[A_j(\mathbf{r})A_l(\mathbf{r}) - < A_j(\mathbf{r})A_l(\mathbf{r}) >] + \cdots$$

- The variable $A_i$ is a slow mode such as the density and velocity field.

- Now, MCT can be understood as a one-loop self-consistent theory.

- Annals Phys. **61**, 1 (1970)

# Kyozi's career (1966-1970)

- He went back to Kyushu University as an assistant professor (Mori's group) in 1966.

- He left Japan for Univ. of Illinois at Urbana-Champaign in 1969.

- He also has a position in Bell Lab. in 1969.

- He moved to Temple University in 1970 as an associate Professor.

- He was quickly promoted to be a Professor in Temple.

# Kawasaki's contributions

- Kawasaki also proposed model H for critical dynamics (Annals Phys. 1970).

- Kawasaki's scaling function for the diffusion coefficient (1970)

- Kawasaki transform as well as Kawasaki-Gunton theory (1974)
  - Similar to Fluctuation theorem

# Kyozi's career (1973-)

- He went back to Japan as a Professor in RIFP (now YITP), Kyoto University in 1973.

- He moved to Kyushu University as a Professor in 1976.

- He retired Kyushu University in 1994.

- After the retirement he was in Konstanz University, Chubu University, Los Alamos (as an Ulam scholar) and Fukuoka Institute of Technology.

# Kyozi's subjects after his went back to Japan

- Critical dynamics in shear flow (with Akira Onuki) in 1979
  - They showed the shift of the critical temperature under shear based on dynamic RG.
- Interface Dynamics, mainly with Takao Ohta (1982-83)
  - They discussed the interaction between kink and antikink.
  - They also got an approximate scaling function of coarsening dynamics of model A after a quench.
  - Their analysis stimulated applied mathematcians.

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# Kyozi's work (cont.)

- Segregation of block-copolymer with Takao Ohta (1985)
  - Strong segregation theory derived from Edwards' Hamiltonian
  - This paper is most cited.

- Glass transition (1990-) with Bongsoo Kim
  - He believed that the glass transition can be described by MCT (proposed by W. Götze).

# His personality
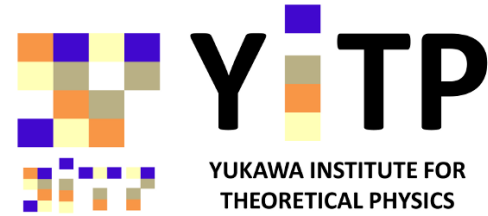
- He was a hard worker.
- He concentrated to study physics even above 60.
  - He had a bed in his office, and worked from the morning to midnight.
- He shut down everything in the morning to concentrate studying physics.
- He was not a good administrator.
  - He refused to be a Department Chair.

# Kawasaki school
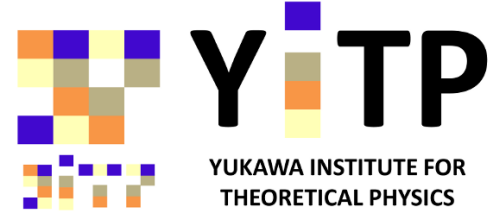
- Jim Gunton (Temple)
- Akira Onuki (Kyoto)
- Takao Ohta (Kyoto)
- Ken Sekimoto (Kyoto->ESPCI)
- Toshihiro Kawakatsu (Tohoku)
- Kazuhiro Fuchizaki (Ehime)
- Tatsuhiro Imaeda (Aichi Gakusen), Yoshihisa Enomoto (Nagoya Inst. Tech.), Hisao Hayakawa (Kyoto), Tetsuo Ogawa (Fukui), Akio Nakahara (Nihon Univ.),Tsuyoshi Koga (Kyoto), Takashi Taniguchi (Kyoto), Tohru Okuzuno (Nagoya City Univ.), Ichiro Moriguchi (Tokyo Univ. Info. Sci.)

# Other related members

- Tomoj
- Tatsuji
- Michio
- Yasuhi
- Yoshi
- Glenn
- David
- Helmu
- Walter
- Bongs Univ.)

Tetsuo Ogawa

Glenn Fredrickson

Me

Akio Nakahara
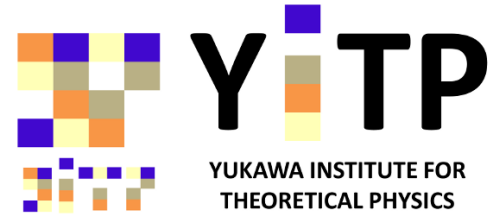
In Yanagawa (1988)

Toshihiro Kawakatsu

Memory of Ryoji Kawasaki

# His awards

- He received the Boltzmann medal in 2001.

- Nishina Memorial Prize in 1972

- Humboldt Prize in 1992

- Toray Science and Technology Prize in 2000

- Ulam sholar in 2001

# Conclusion

- He was a world traveler.

- He was a great scholar of nonequilibrium statistical mechanics, in particular, for critical dynamics.

- His influence to nonequilibrium statistical mechanics is still big.

- Thank you for your attention.