Junturas Josephson: componentes disipativas y no disipativas DC ante un bias DC

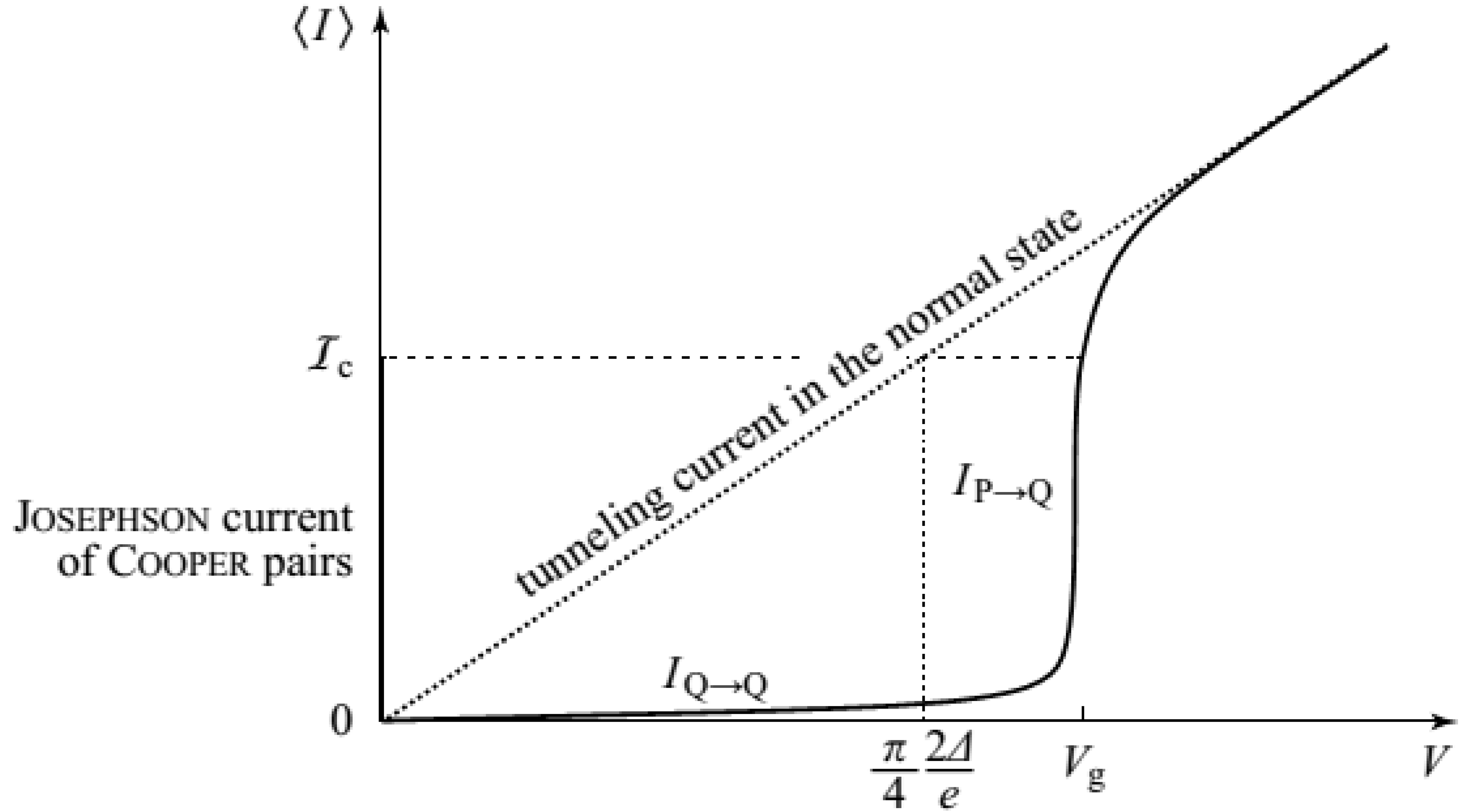

Figure 10.4 - Characteristics of an SIS junction linked to a voltage generator at low temperatures

The time-averaged intensity $\langle I \rangle$ across the junction is the superposition of three components:

› the d.c. JOSEPHSON effect, that provides an intensity between $+I_c$ and $-I_c$ for $V = 0$,

› $I_{P\to Q}$: the tunneling current of quasiparticles created by the disassociation of COOPER pairs at the junction when the potential exceeds $V_g = 2\Delta/e$,

› $I_{Q\to Q}$: the tunnel current of quasiparticles created by the thermal break-up of COOPER pairs inside each superconducting block.

Junturas Josephson: fluctuaciones térmicas

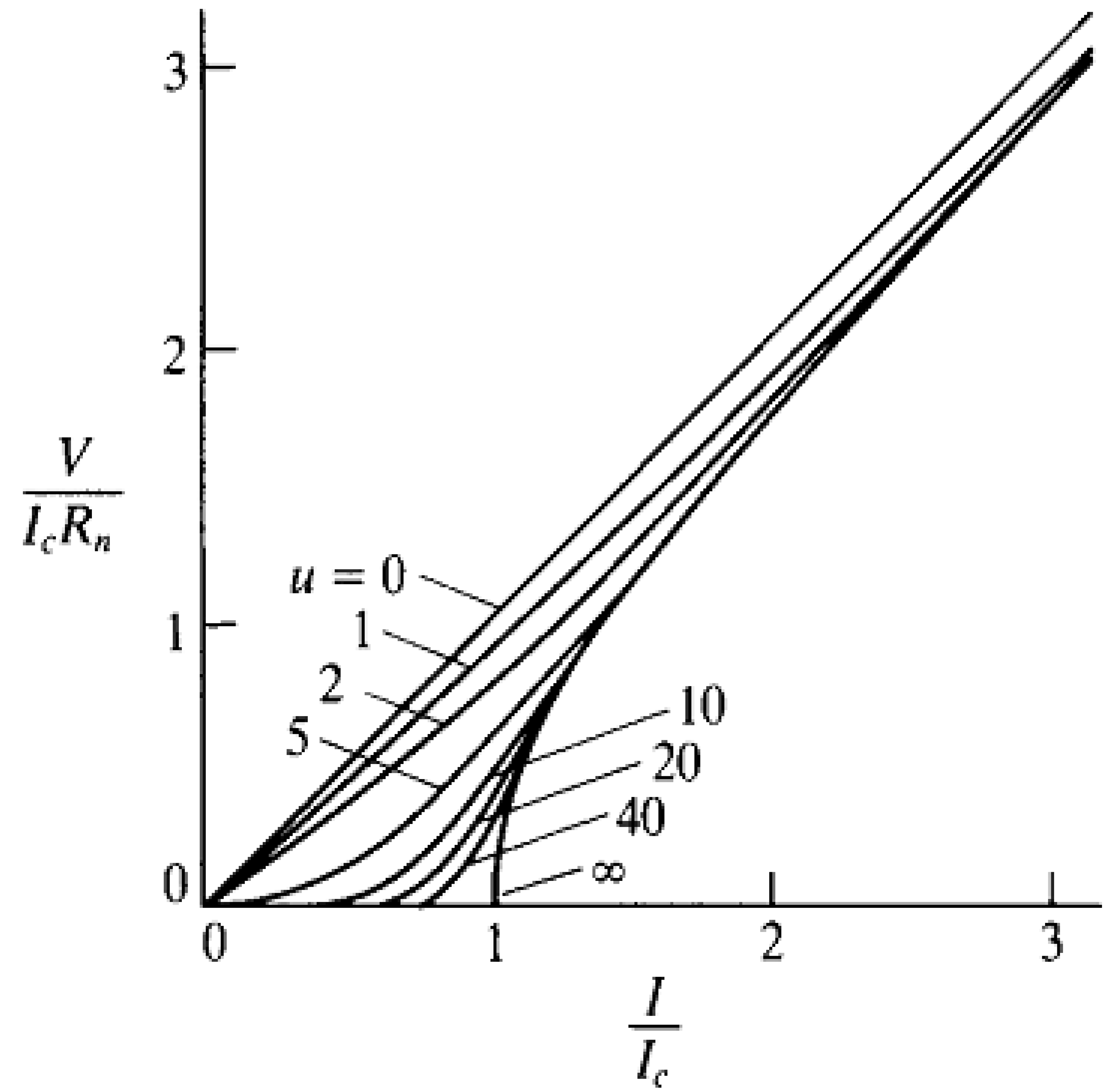

FIGURE 6.6
I-V characteristics of overdamped junction in the presence of thermal activation, as found by Ambegaokar and Halperin; here $u = \hbar I_c / ekT$.

JJ sobreamortiguadas (Q<<1)

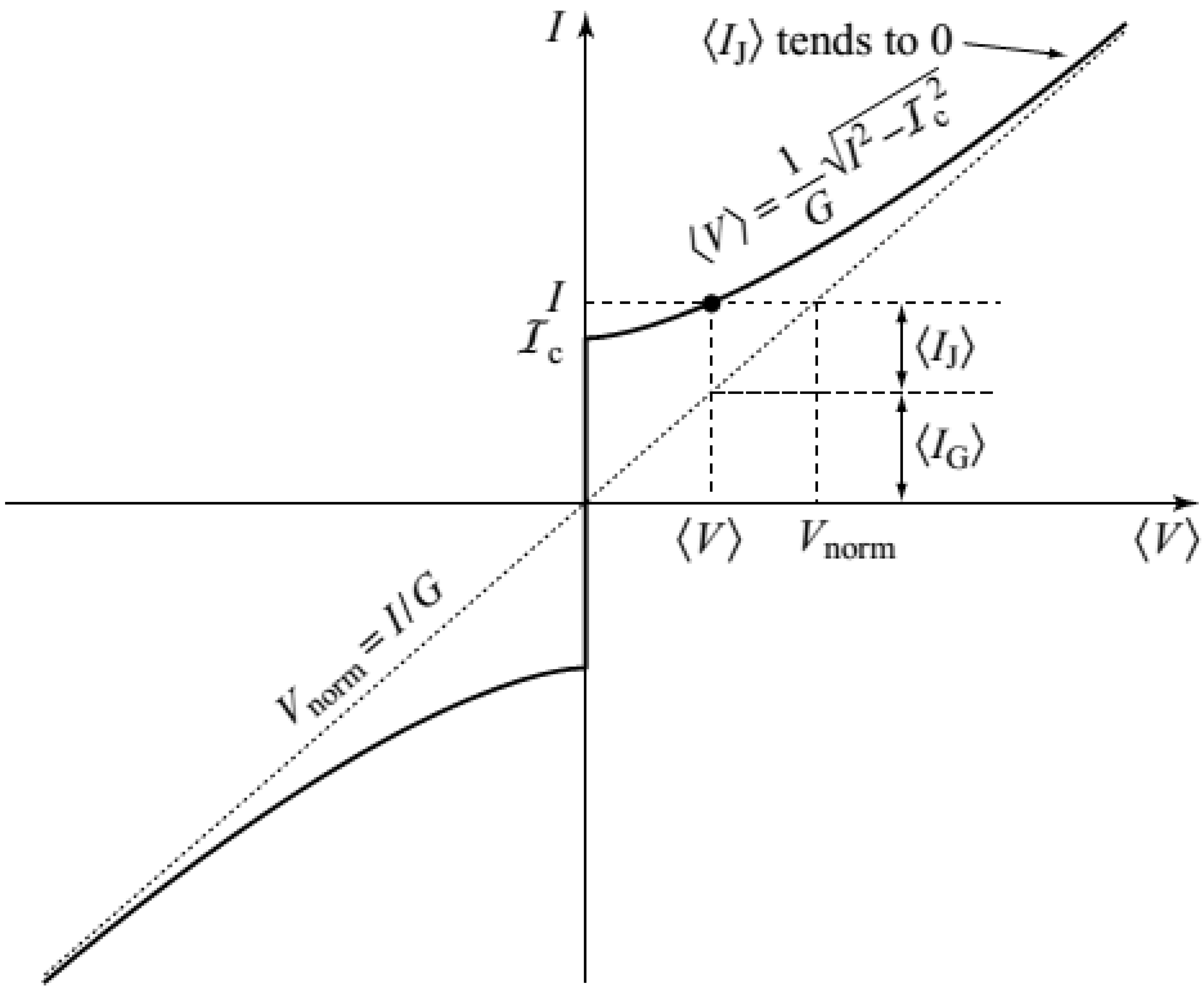

Figure 10.10 - Current-voltage characteristics of the current-biased RCSJ circuit in the over-damped regime ($\beta_c = 0$)

$\langle V \rangle$ is the time-averaged value of the voltage at the leads of the superconducting junction with injected current I. V_{norm} is the voltage at the junction leads in the normal state with the same current, $\langle I_J \rangle$ the time-averaged JOSEPHSON intensity and $\langle I_G \rangle$ the time-averaged current intensity across the conductance G.

JJ sobreamortiguadas (Q<<1): dependencia temporal

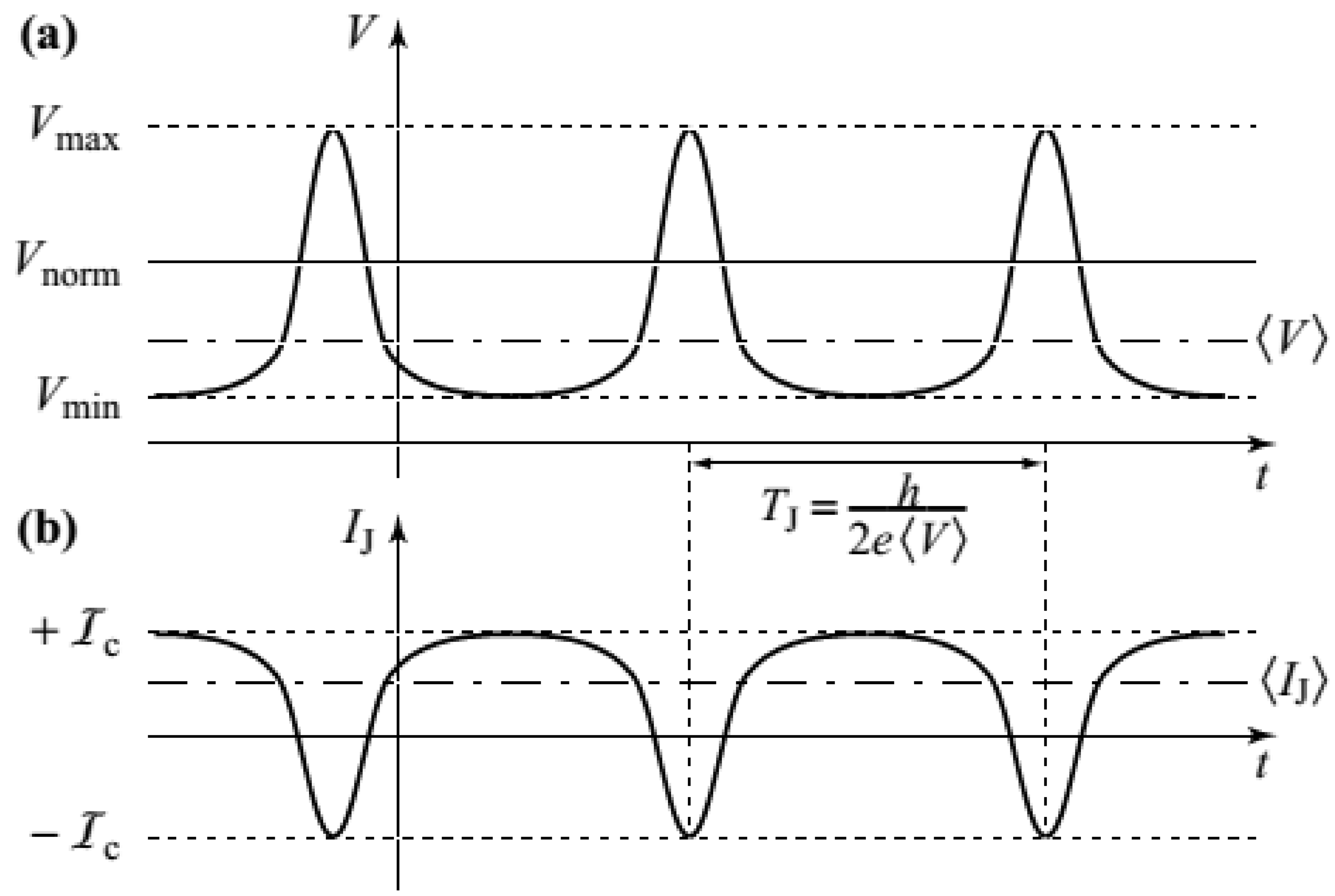

Figure 10.8 - JOSEPHSON current and voltage at the leads of the over-damped RCSJ circuit ($\beta_c = 0$) biased by a current $I > I_c$

(a) The voltage varies periodically. It appears in the form of peaks that are more and more marked as the intensity approaches I_c (from above). V_{norm} is the voltage that would appear at the leads of the device if the junction were normal. **(b)** The JOSEPHSON current shows inverted peaks and varies with the same period betwee n the values $+I_c$ et $-I_c$. Its average value $\langle I_J \rangle$ is always positive.

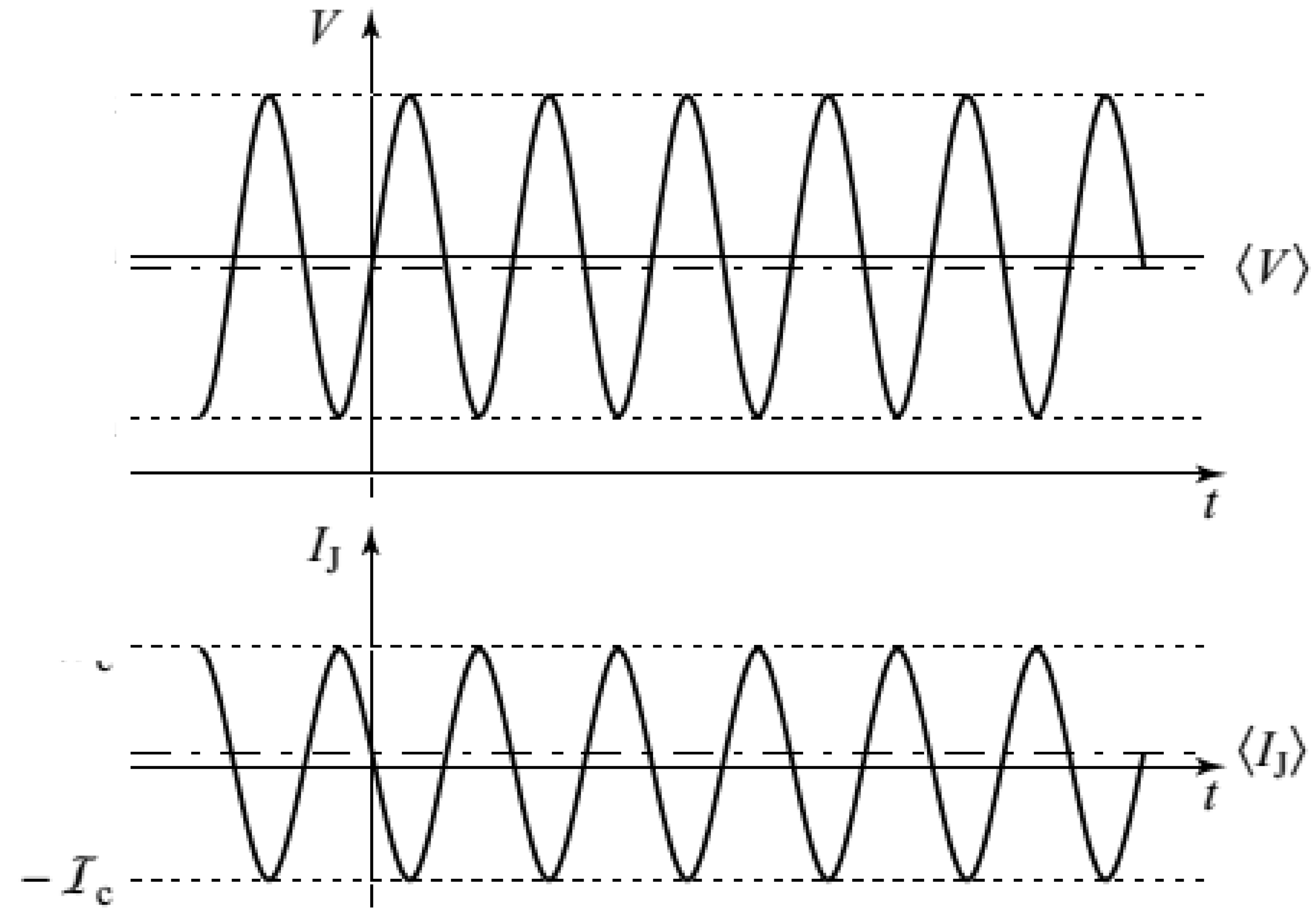

Figure 10.9 -JOSEPHSON current and voltage at the leads of the over-damped RCSJ circuit ($\beta_c = 0$) driven by a current $I \gg I_c$

The curves of Figure 10.8 have the asymptotic form of a sine wave with increasing frequency. The time-averaged value $\langle I_J \rangle$ of the JOSEPHSON current tends to 0.

JJ subamortiguadas : factor Q e histeresis

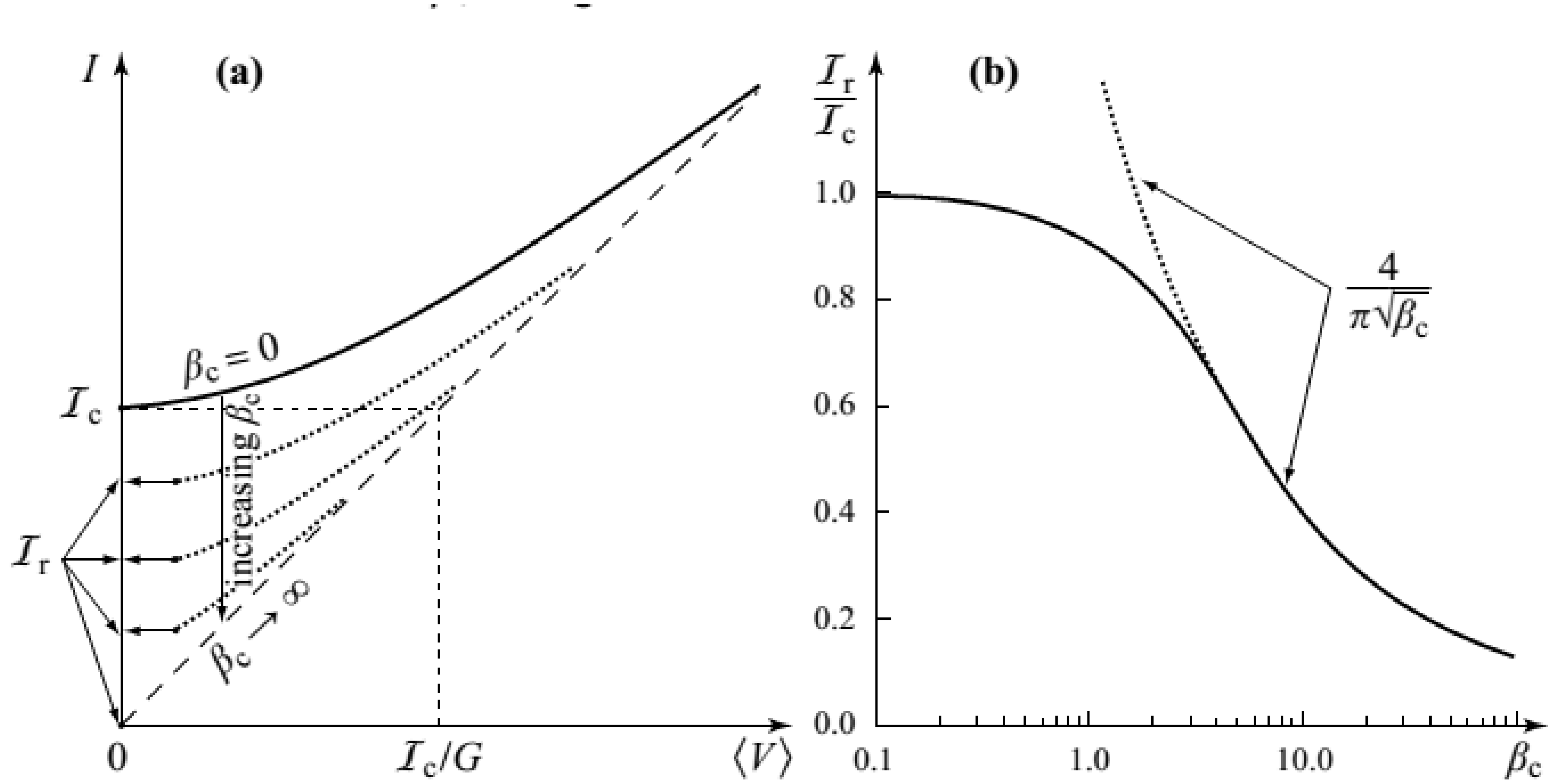

Figure 10.11 - Voltage of return and re-trapping current in an under-damped JOSEPHSON junction
(a) During the decrease of the biasing current the average voltage decreases, following curves that depend on the STEWART-MCCUMBER parameter β_c. The voltage reaches zero for an intensity I_r called the re-trapping current. **(b)** Relative value of the re-trapping current as a function of the parameter β_c. The continuous line corresponds to the exact calculation. The dotted line is the result of the calculation made in section 10.4.9, valid when β_c is sufficiently large.

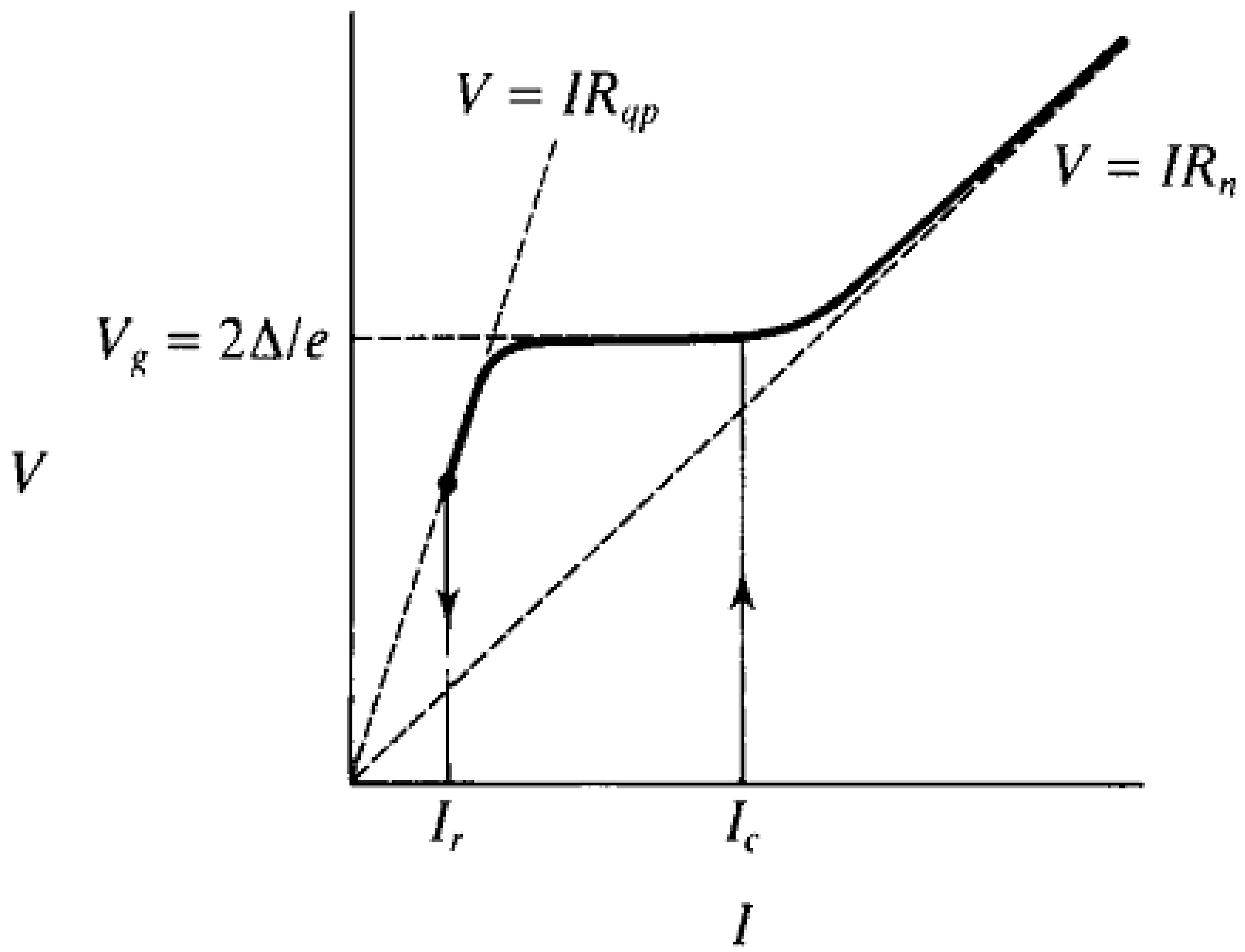

FIGURE 6.4
Hysteretic I-V curve of an underdamped Josephson junction. (Schematic.)

JJ SIS

Figure 10.12 presents schematically a typical JOSEPHSON junction used as a voltage standard.[10]

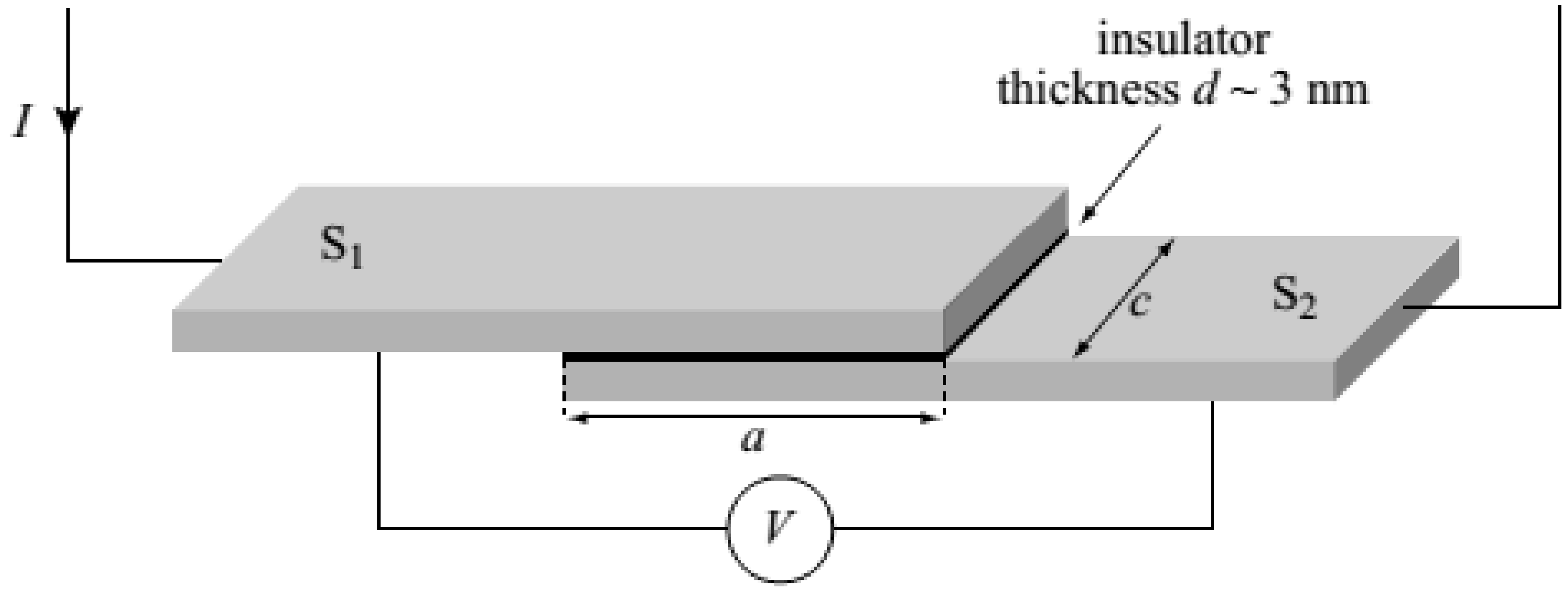

Figure 10.12 - Schematic image of a typical SIS junction
It is formed by two superconducting films of width c, that are superimposed for a length a over which they are separated by an insulator of thickness $d \sim 3$ nm.

» $Nb/Al_2O_3/Nb$ [10] (niobium gap: $\Delta = 1.5$ meV) $c = 30$ µm and $a = 18$ µm
This junction displays a critical intensity $\mathcal{I}_c \approx 110$ µA, or a critical current density $\mathcal{J}_c = \mathcal{I}_c / ca \cong 20$ A cm^{-2} and a resistance $\mathcal{R}_n$ of order 20 Ω;

» $Al/Al_2O_3/Al$ [11] (aluminum gap: $\Delta = 0.175$ meV) $d \sim 2$ nm
For a cross-section ≈ 2 µm^2, $\mathcal{R}_n \approx 100$ Ω and $\mathcal{I}_c \approx 2$ µA.
For a cross-section ≈ 0.02 µm^2, $\mathcal{R}_n \approx 10$ kΩ and $\mathcal{I}_c \approx 20$ nA.
So for this type of junction a critical current density $\mathcal{J}_c \cong 200$ A cm^{-2};

» $Nb/AlO_x/Nb$
These junctions can attain critical current densities of the order of $\mathcal{J}_c \cong 1$ to 10 kA cm^{-2} for cross-sections of a few µm^2.

JJ SNS

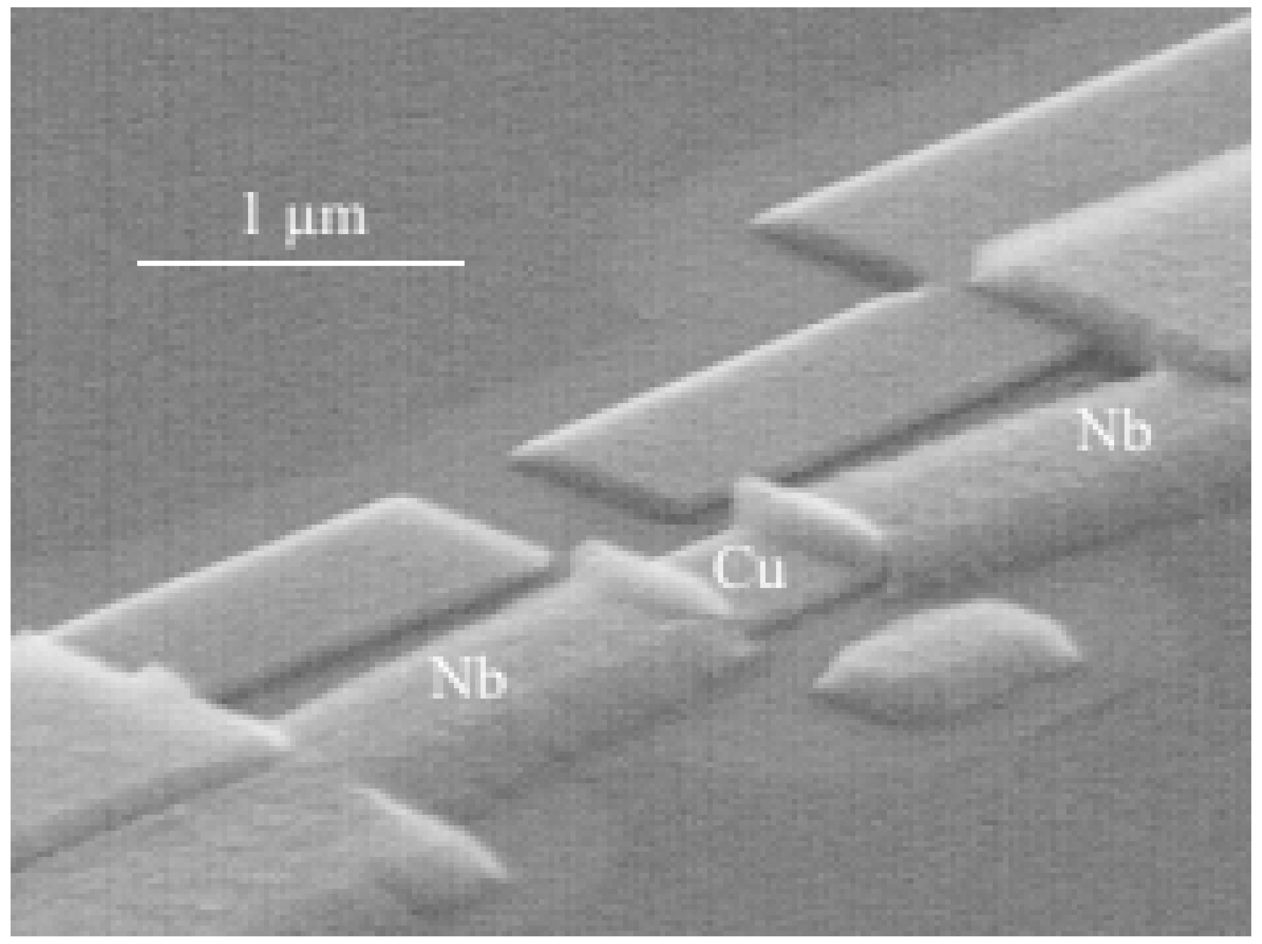

Figure 10.18
Nb/Cu/Nb junction
Junction obtained by deposition at different incident angles with a suspended mask. The technique inherently produces some replicas as well as the Nb/Cu/Nb junction, but being disconnected from the sample they are of no consequence. [From DUBOS *et al.*, 2001, © The American Physical Society, with permission] [25]

To ensure the contact between metals, the niobium covered the copper at each of its extremities over a distance of 150 nm. Typically, when the distance between the niobium electrodes was 500 nm, a resistance $\mathcal{R}_n \approx 0.20\ \Omega$ and a critical current $\mathcal{I}_c \approx 1.2$ mA were found.[25]

Junturas Josephson con rf: saltos de shapiro

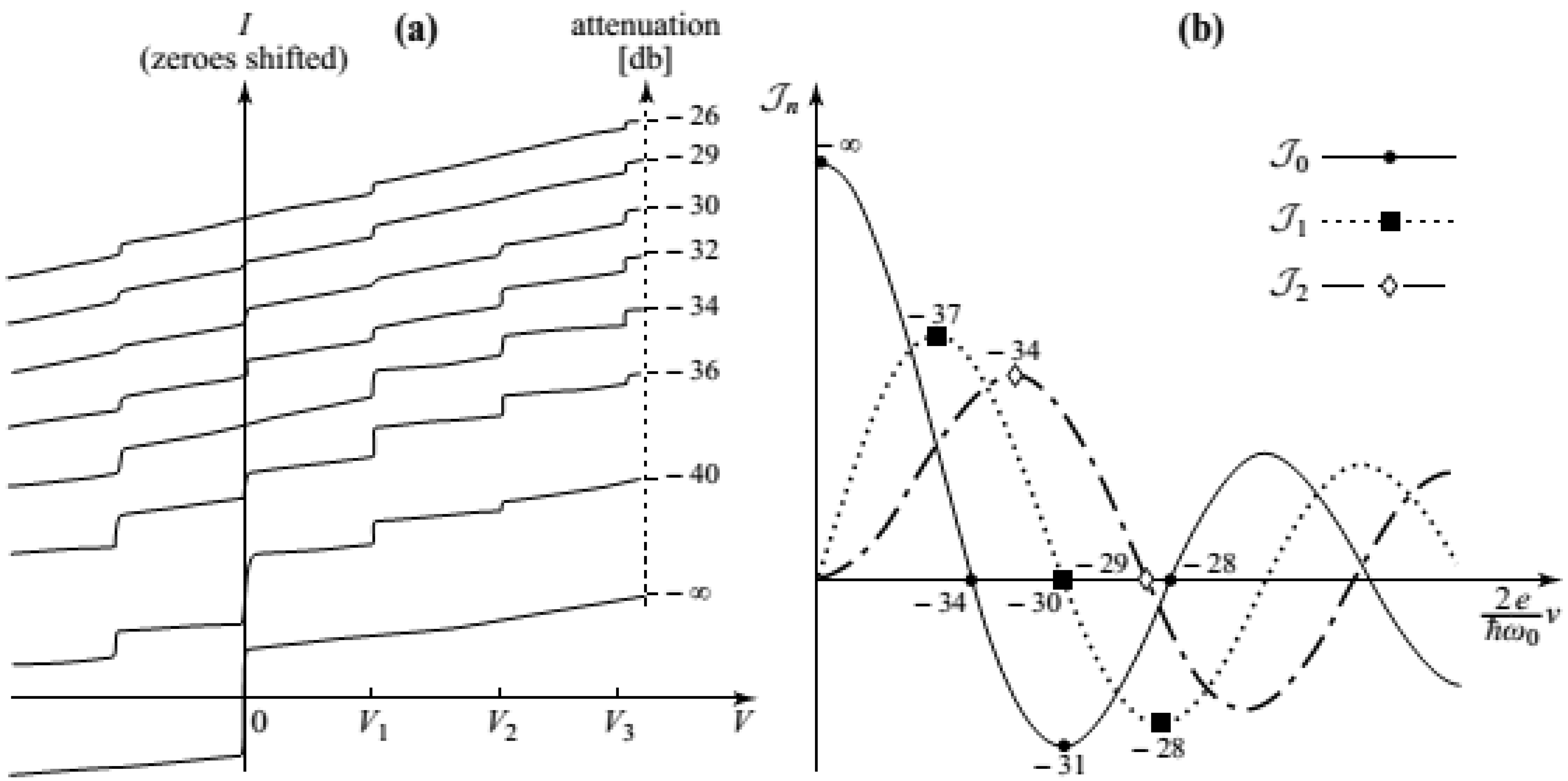

Figure 10.14 - SHAPIRO steps measured on a point contact Nb-Nb JOSEPHSON junction in the over-damped regime

(a) Voltage-current curves obtained at 4.2 K on a junction exposed to an electromagnetic wave of frequency 72 GHz for different degrees of attenuation. The curves have been shifted vertically for clarity. [Curves adapted from Reference 14]

(b) BESSEL functions $\mathcal{J}_0$, $\mathcal{J}_1$ and $\mathcal{J}_2$ for which we note the attenuations corresponding to maxima and minima of the steps situated at V_0, V_1, V_2 of part **(a)** of the figure.