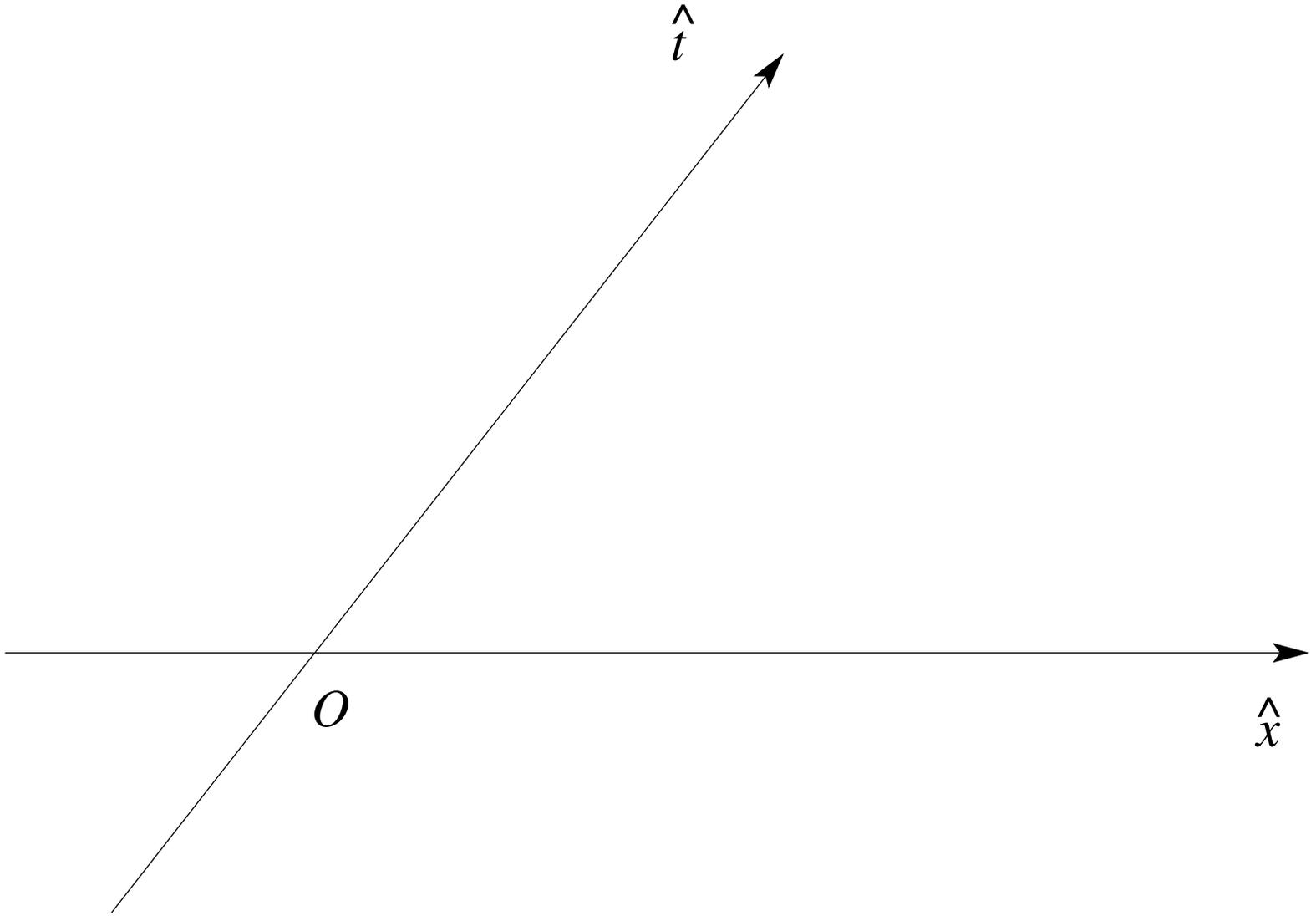
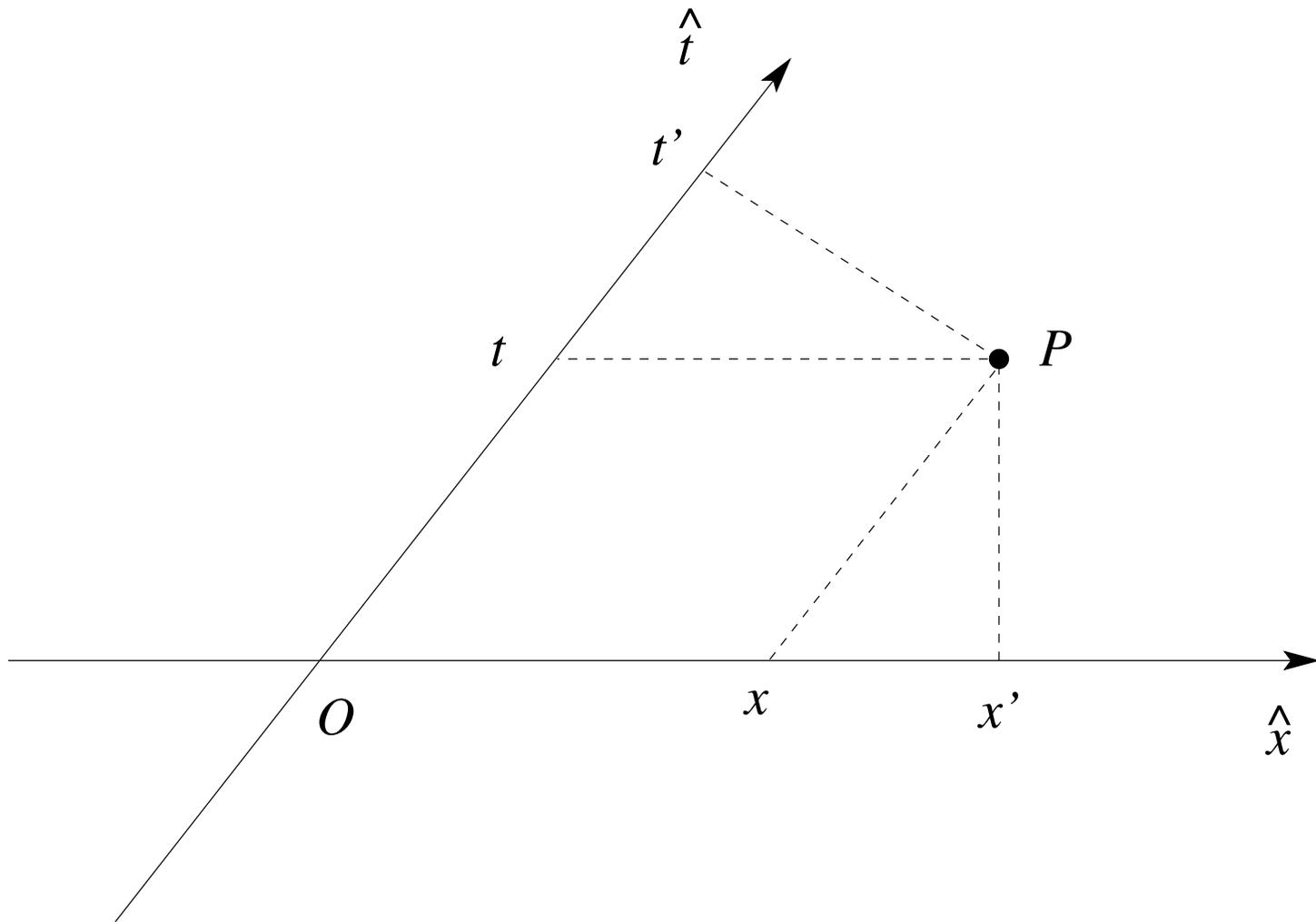


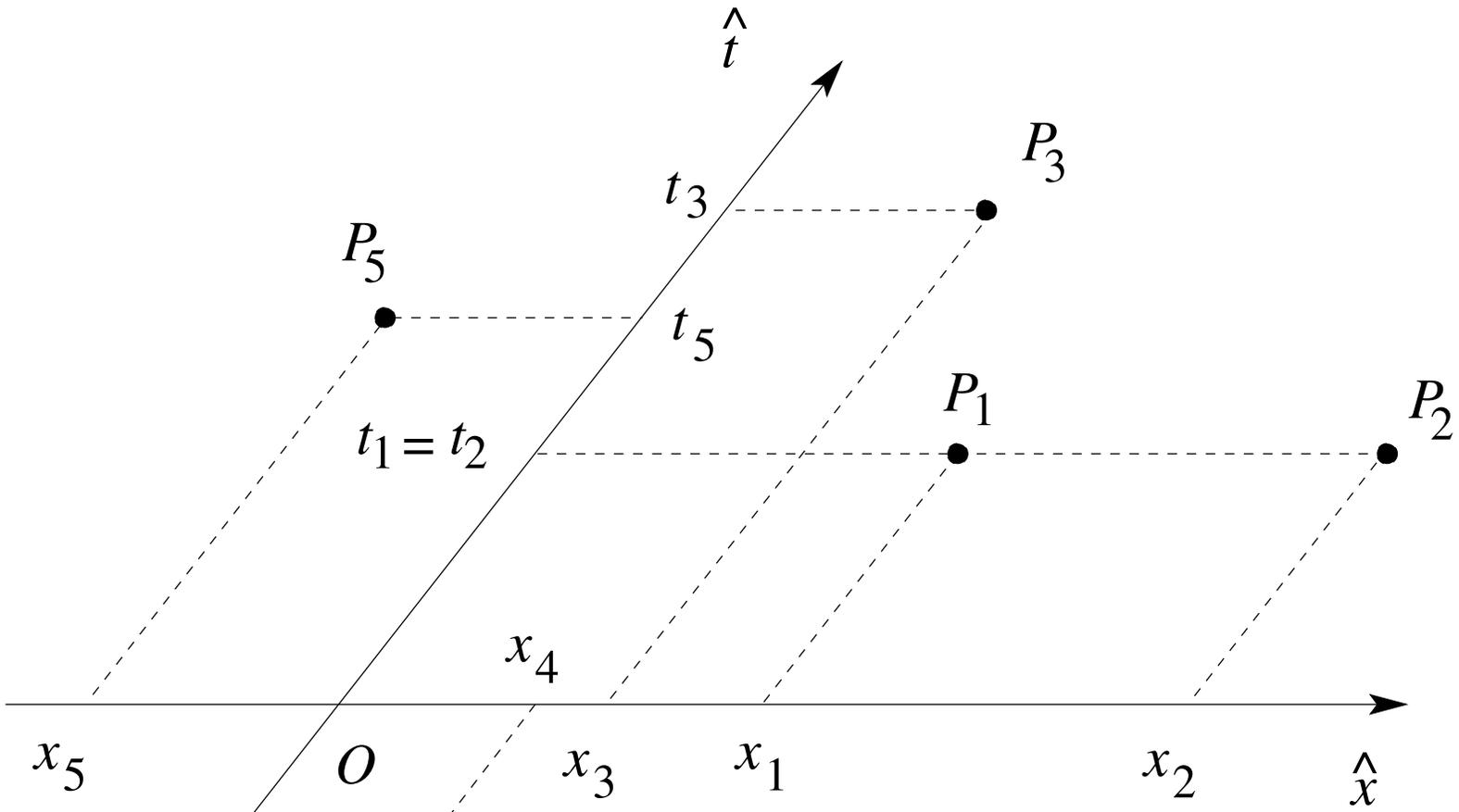
Coordenadas cartesianas



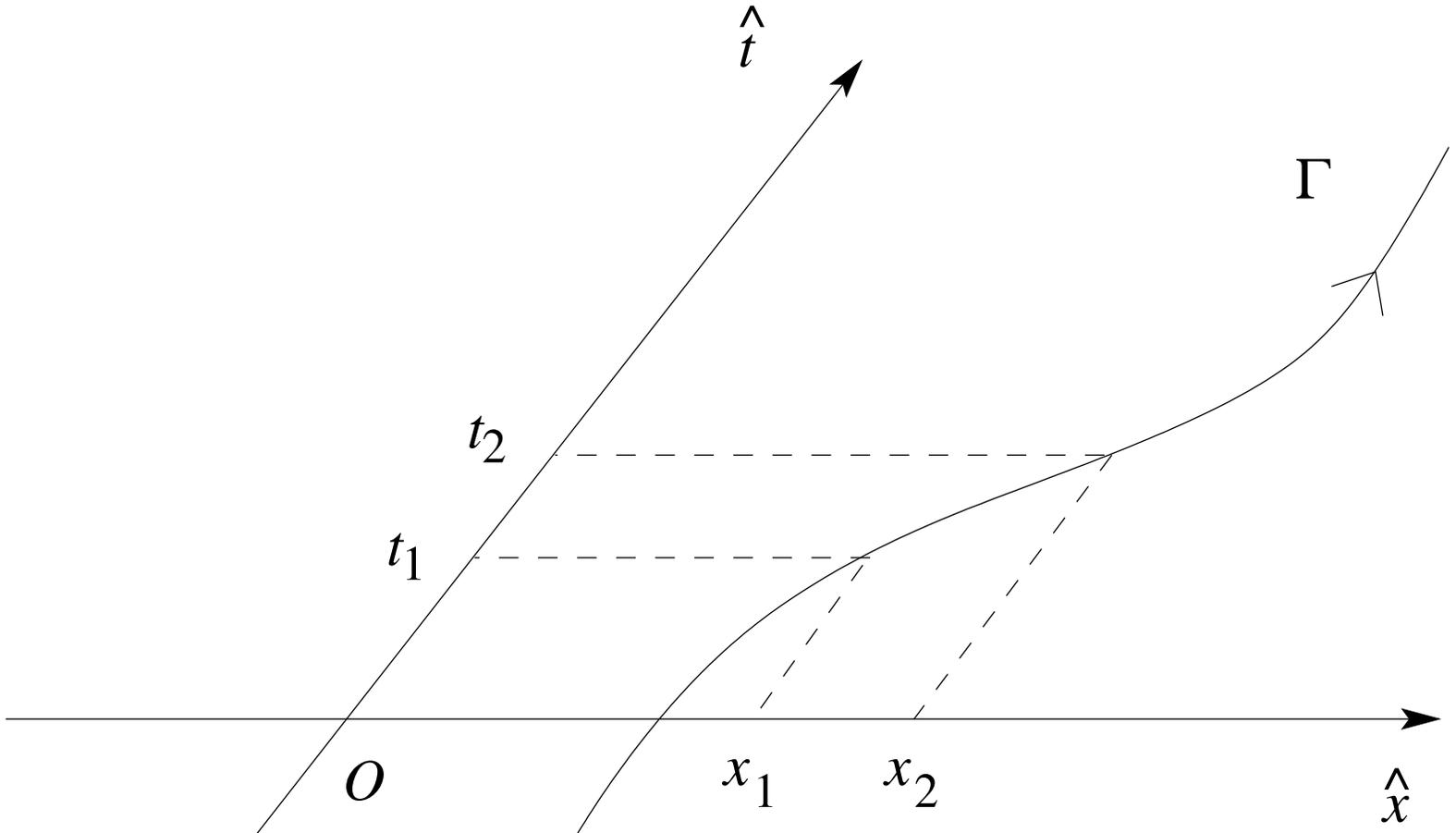
Ejes coordenados oblicuos



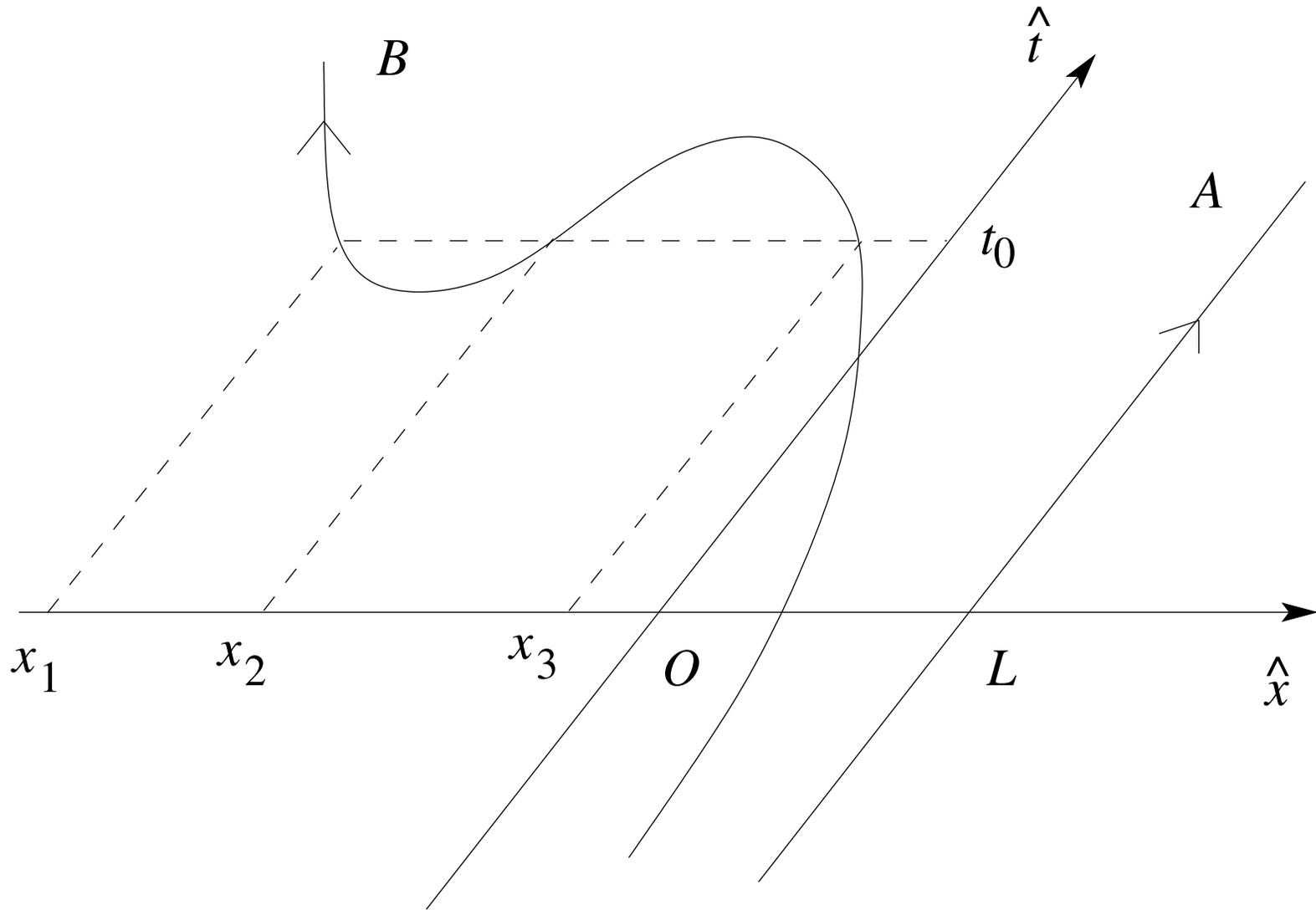
Gráficos de Loedel. Coordenadas covariantes y contravariantes.



Eventos

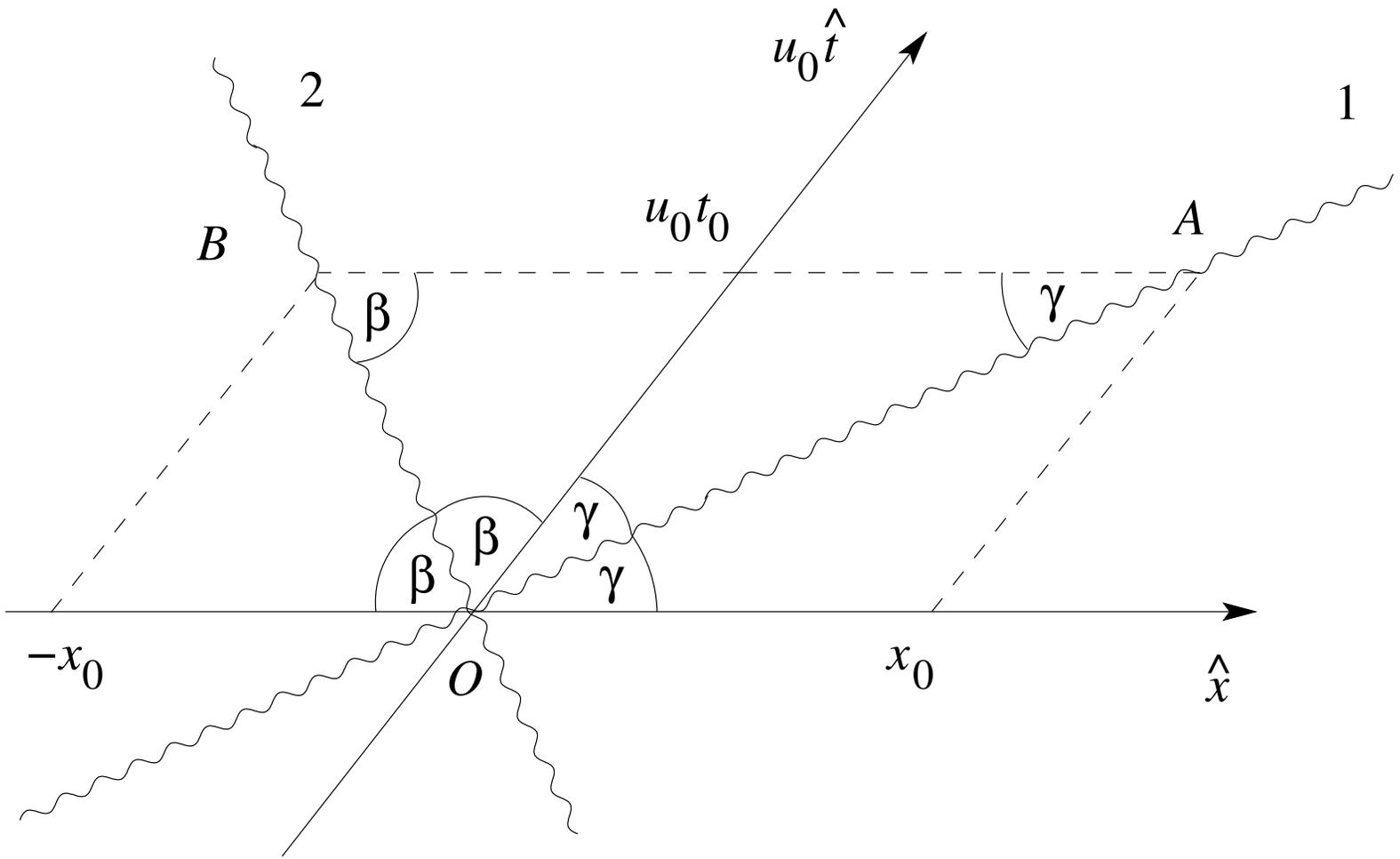


Línea de vida

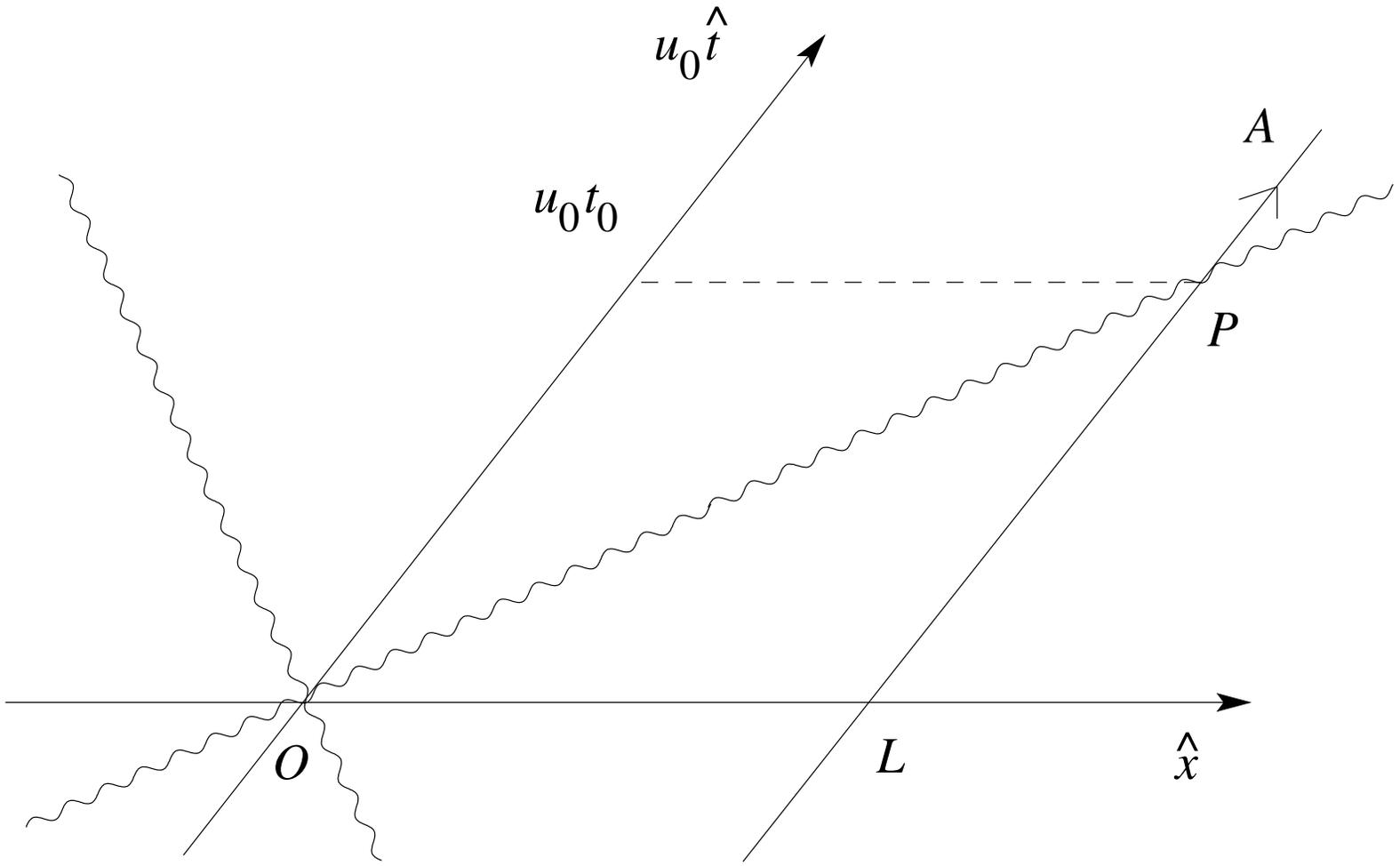


Un objeto en reposo y una línea de vida imposible

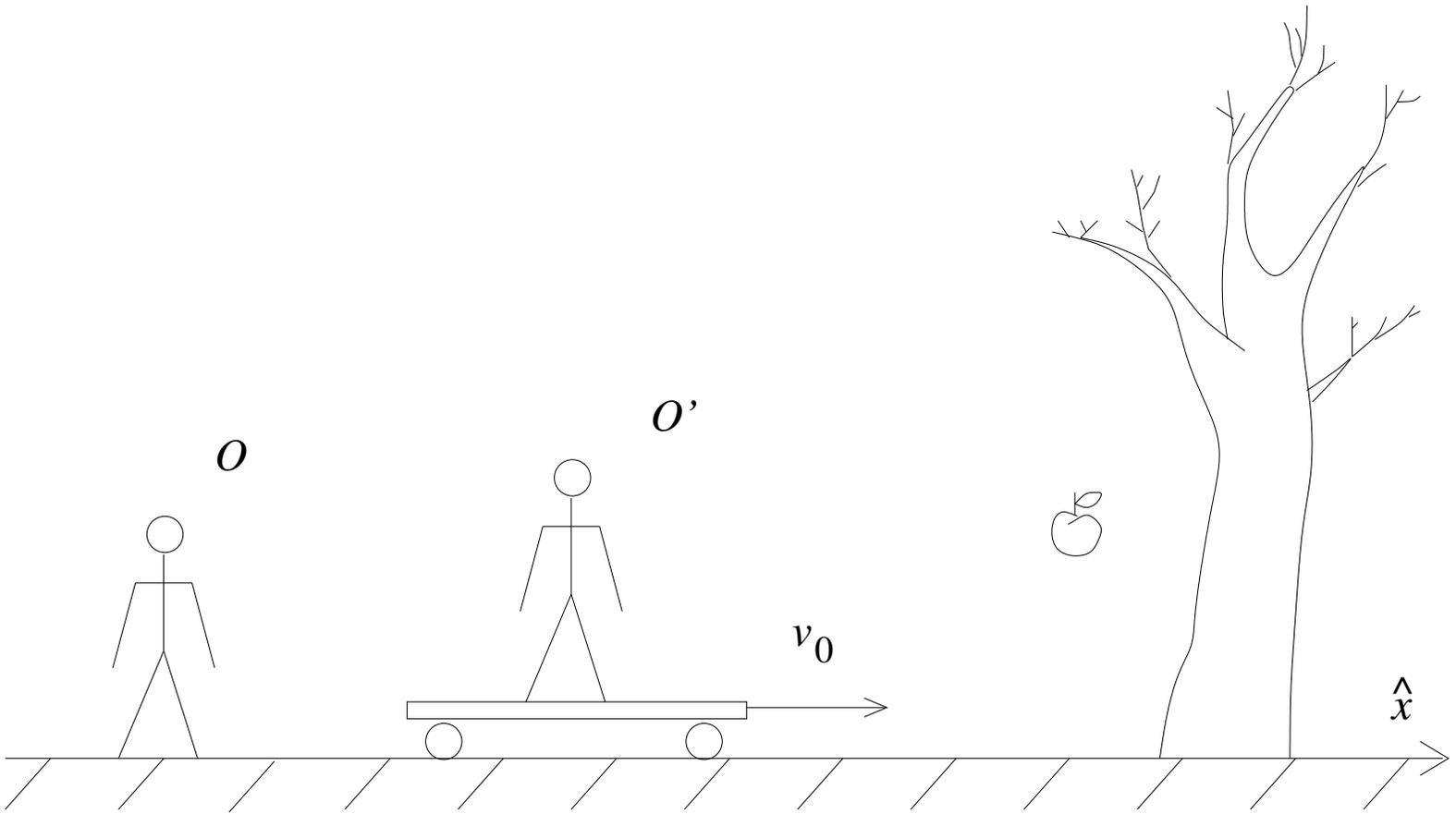




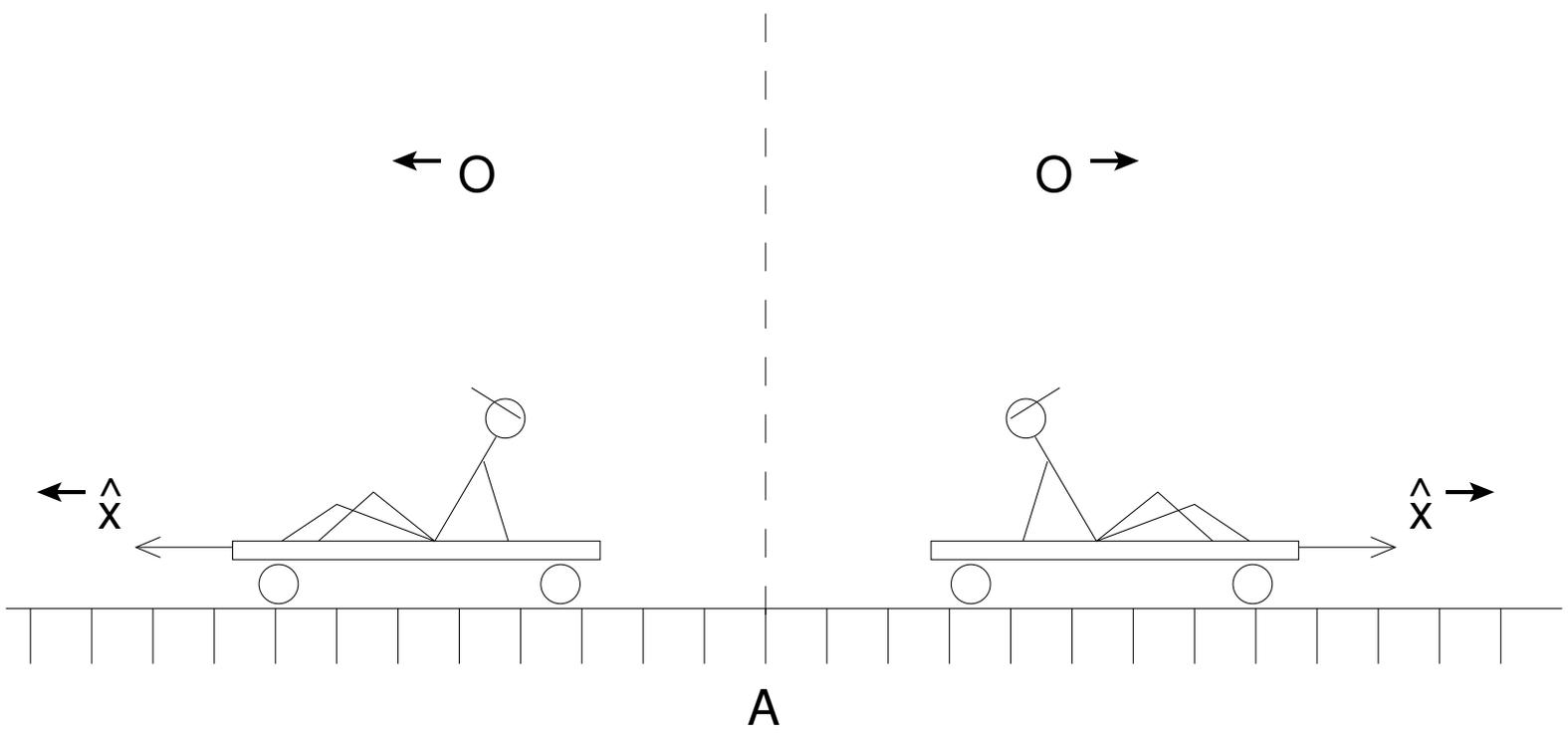
Bisectrices

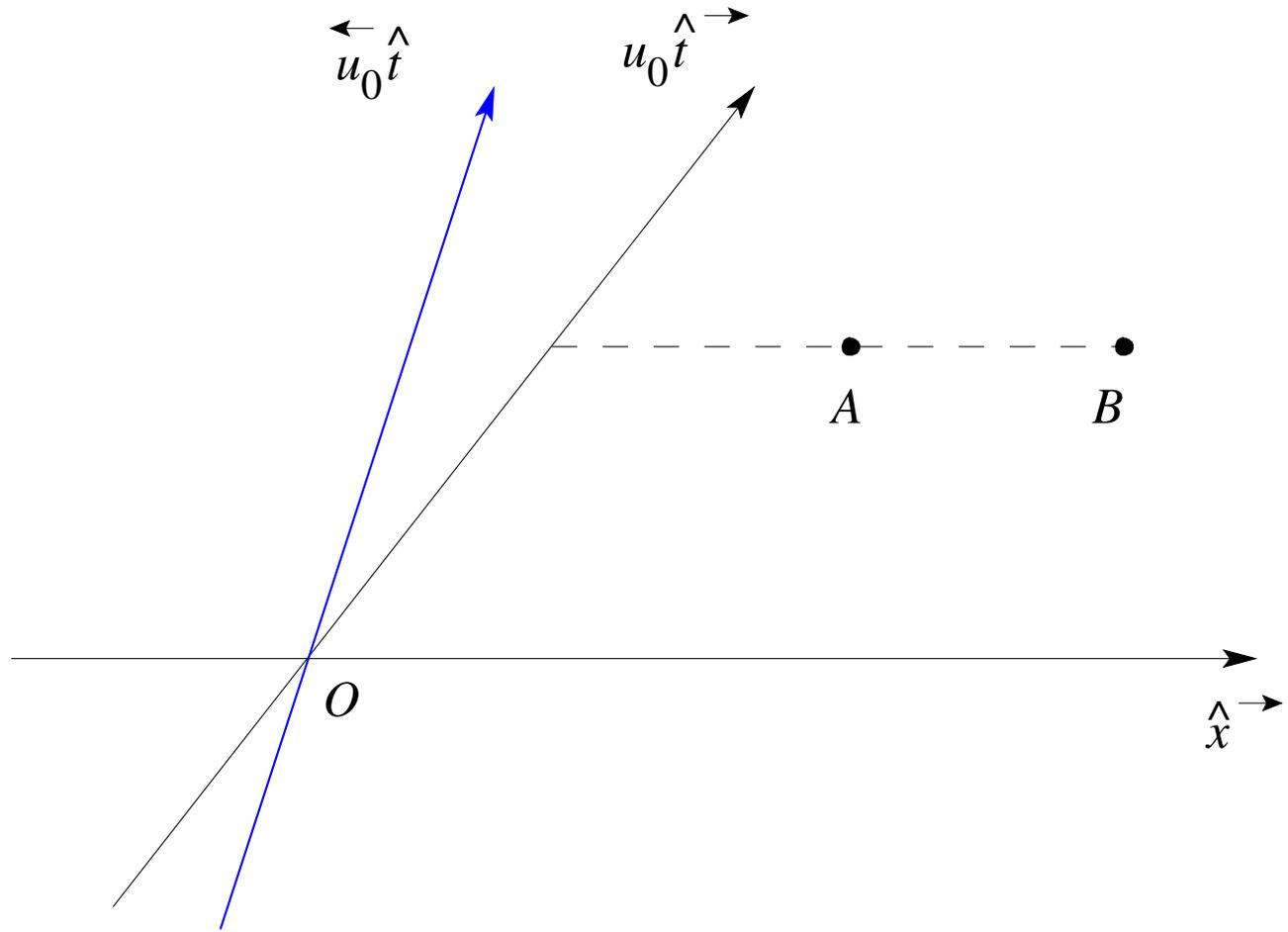


Propagación del sonido hasta un observador en reposo

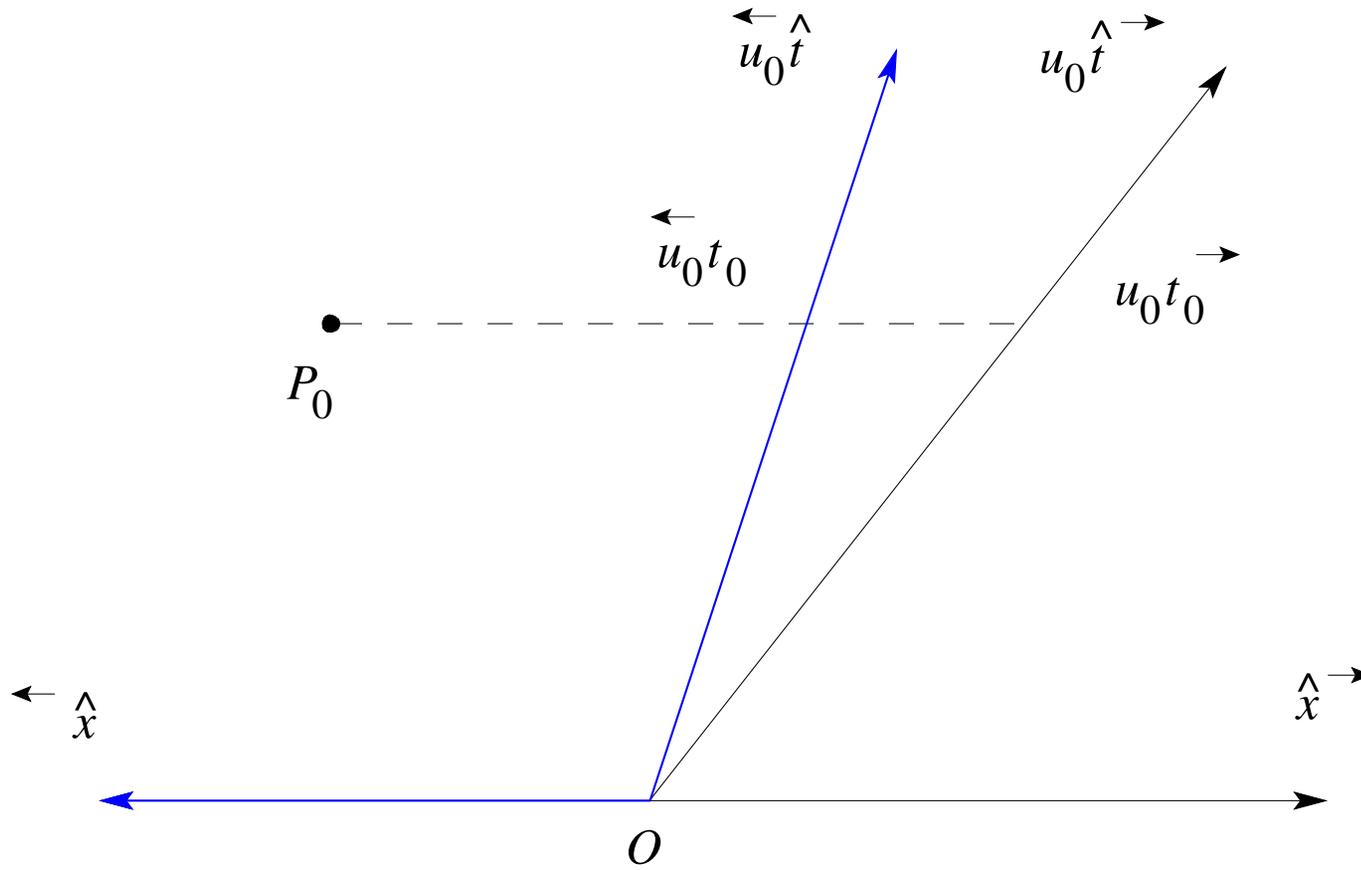


Dos observadores contemplando la caída de una manzana

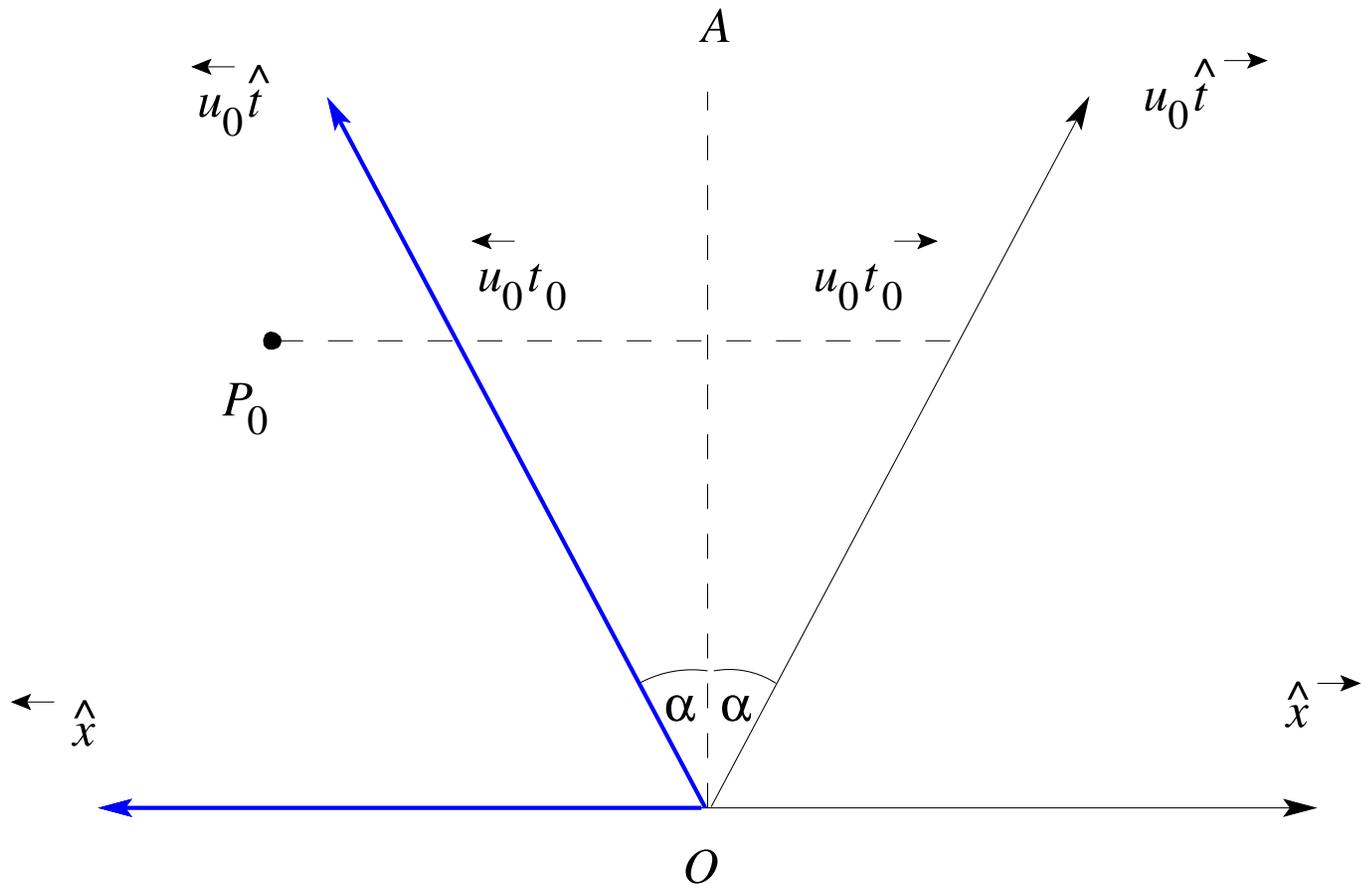




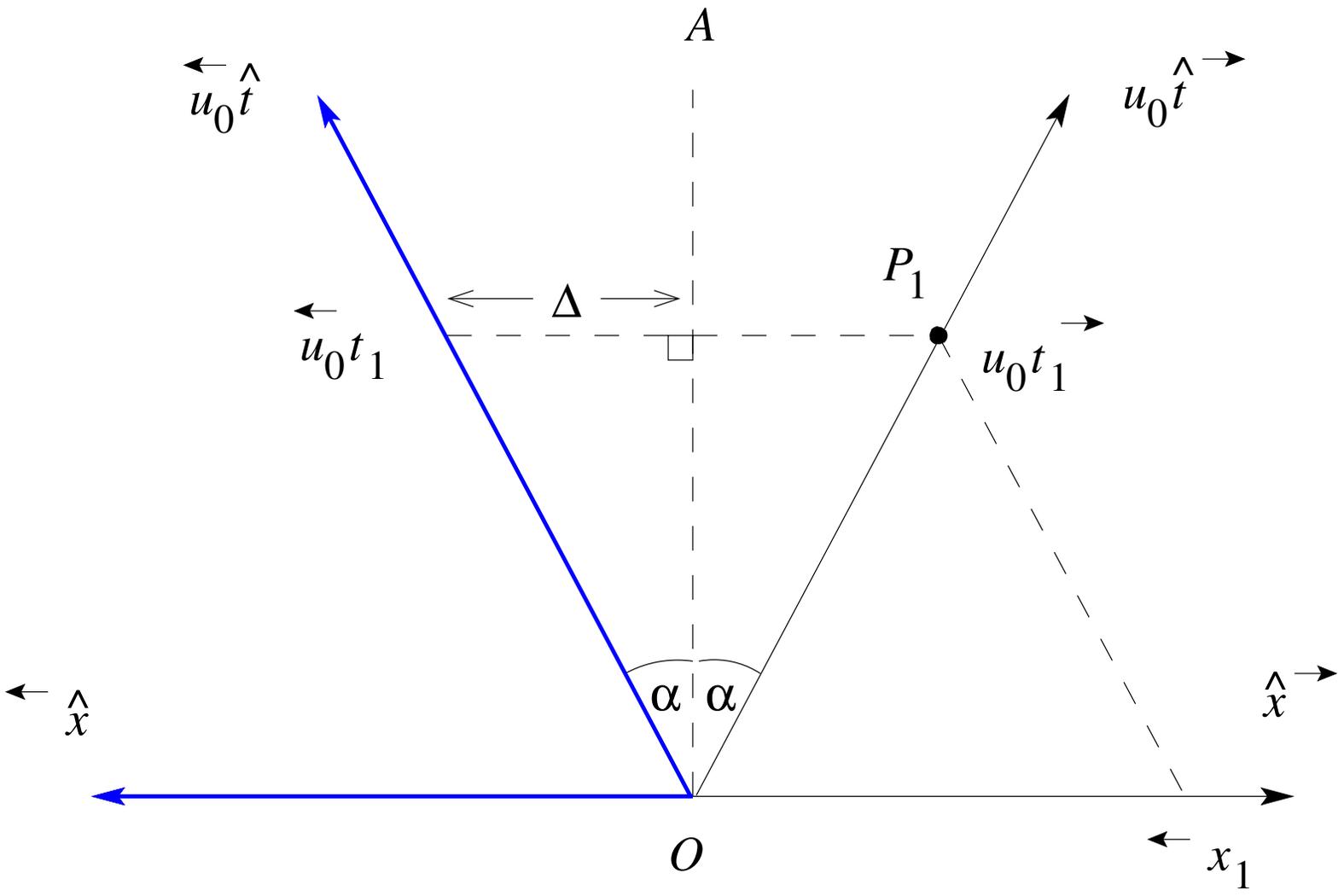
Referencial para observador  $O \rightarrow$ , con la línea de vida del observador  $\leftarrow O$



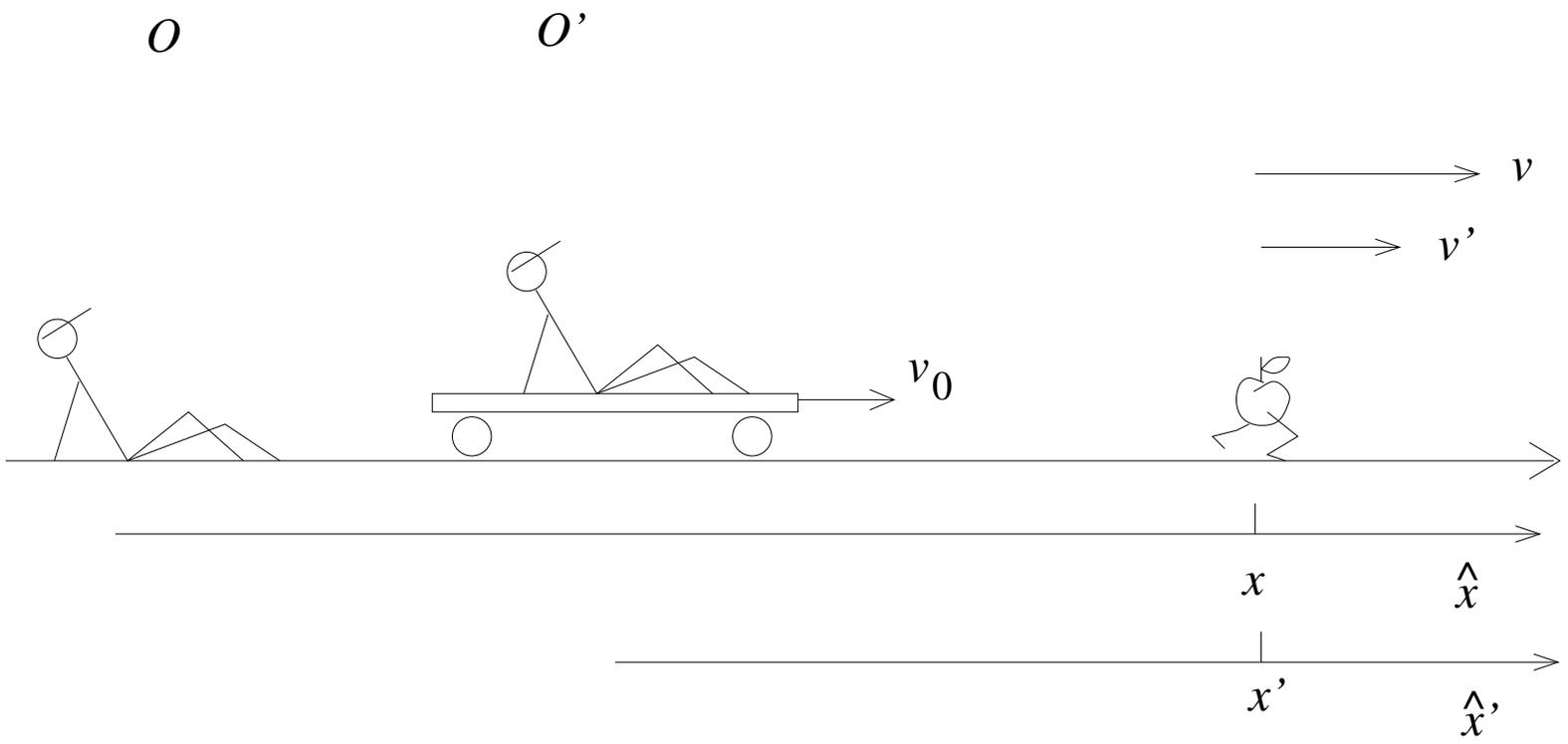
Referenciales espacio-temporales para dos observadores. Primera versión.

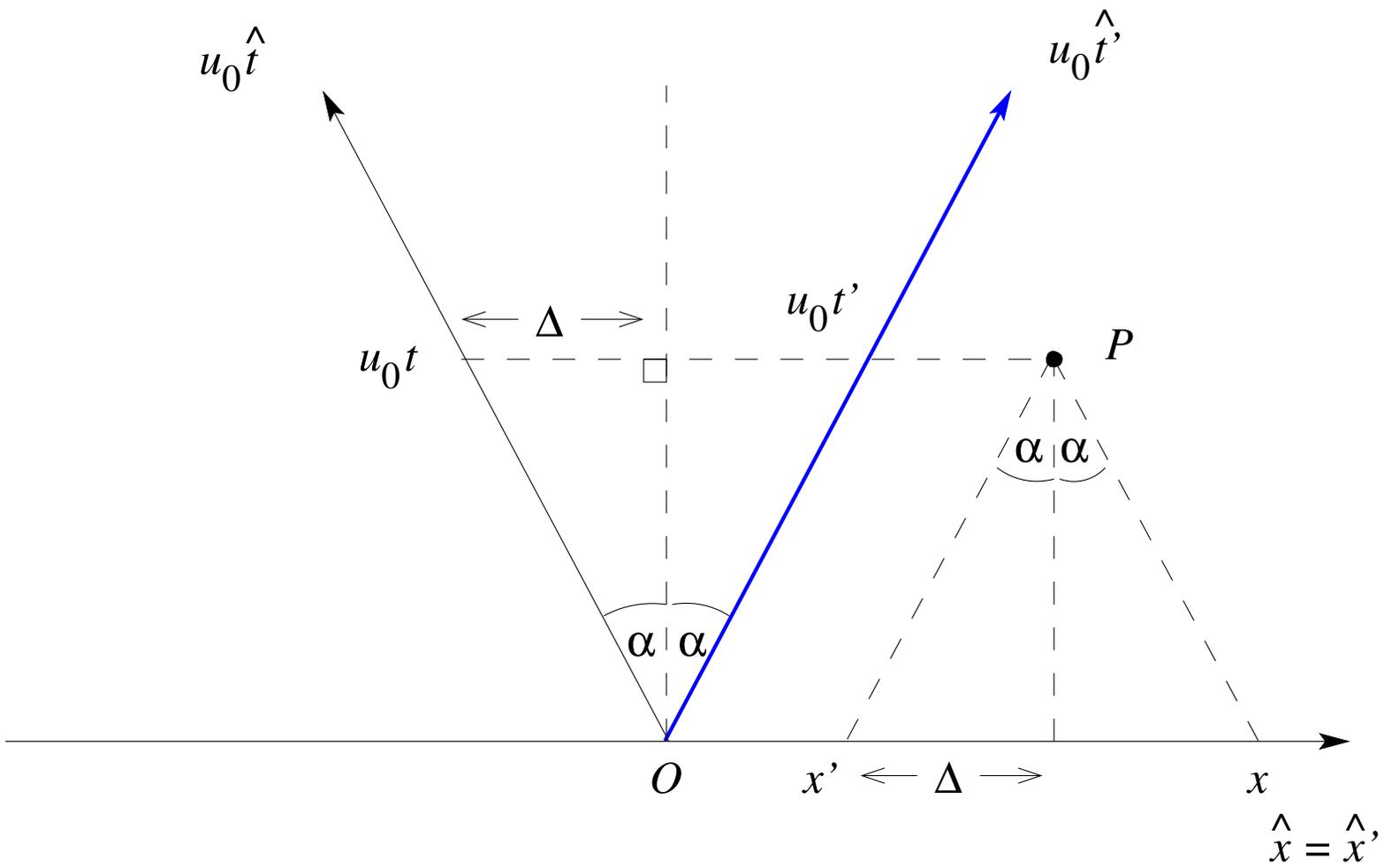


Referenciales espacio-temporales para dos observadores. Segunda versión.

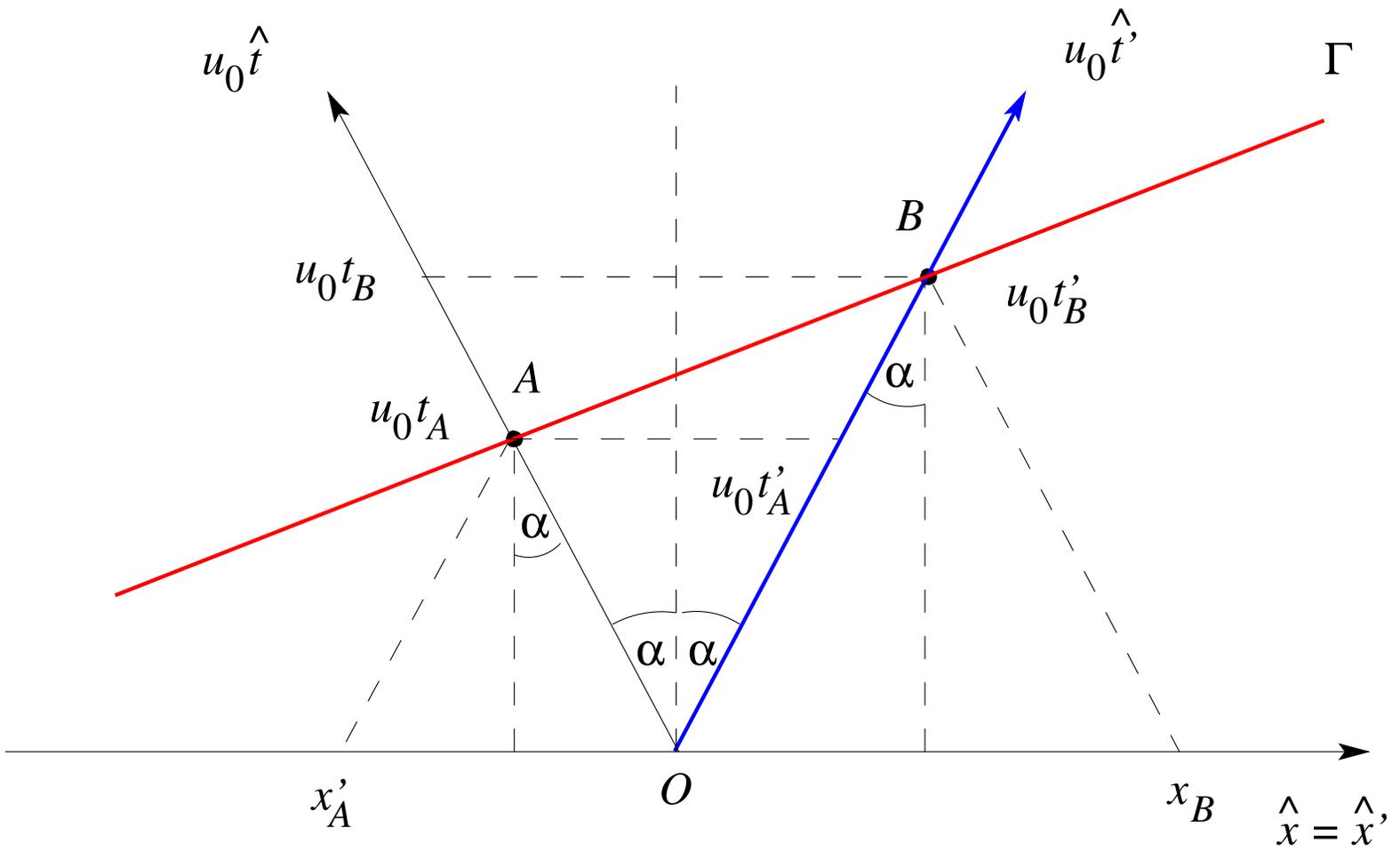


Relación entre ángulo  $\alpha$  y velocidad relativa  $v_0$

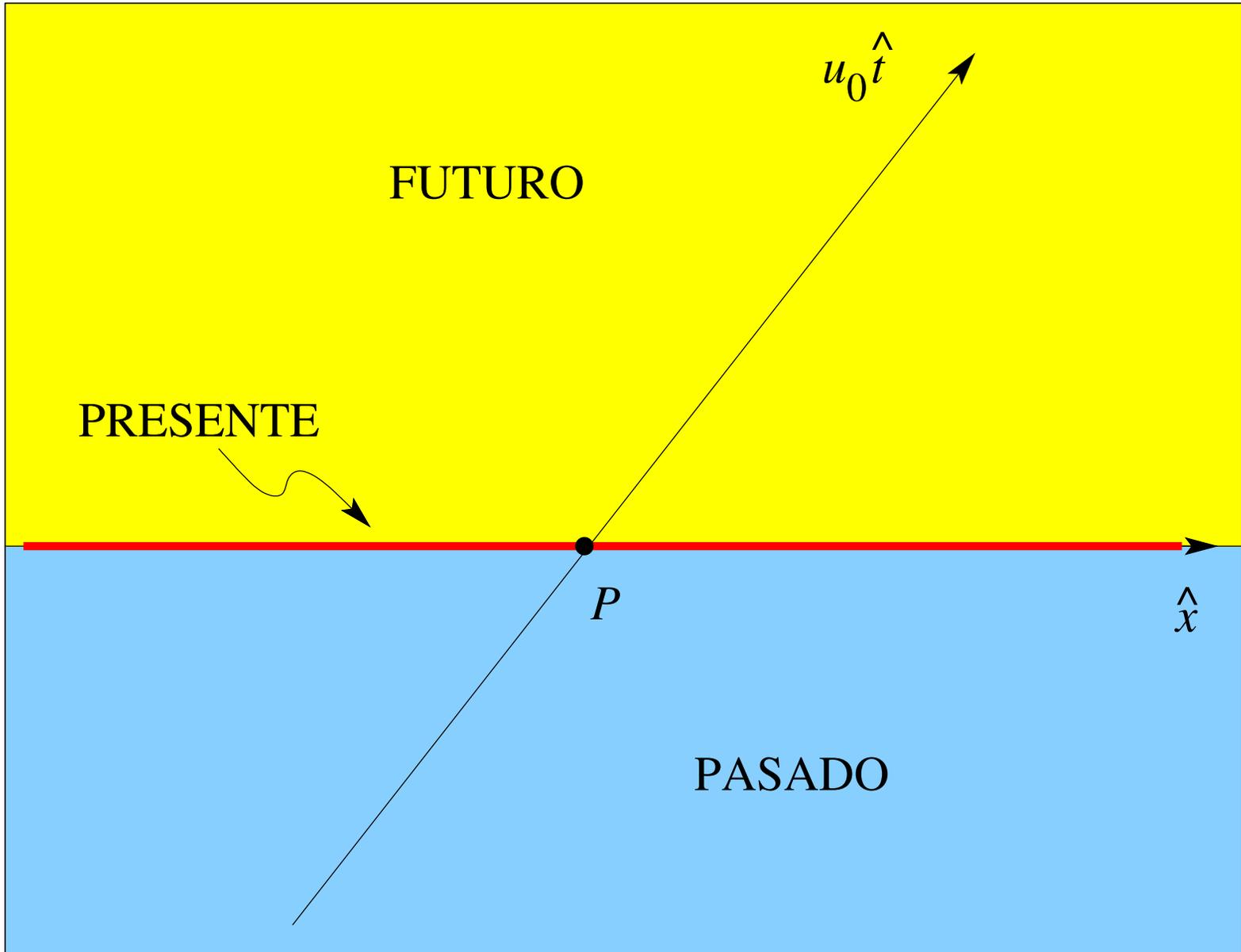




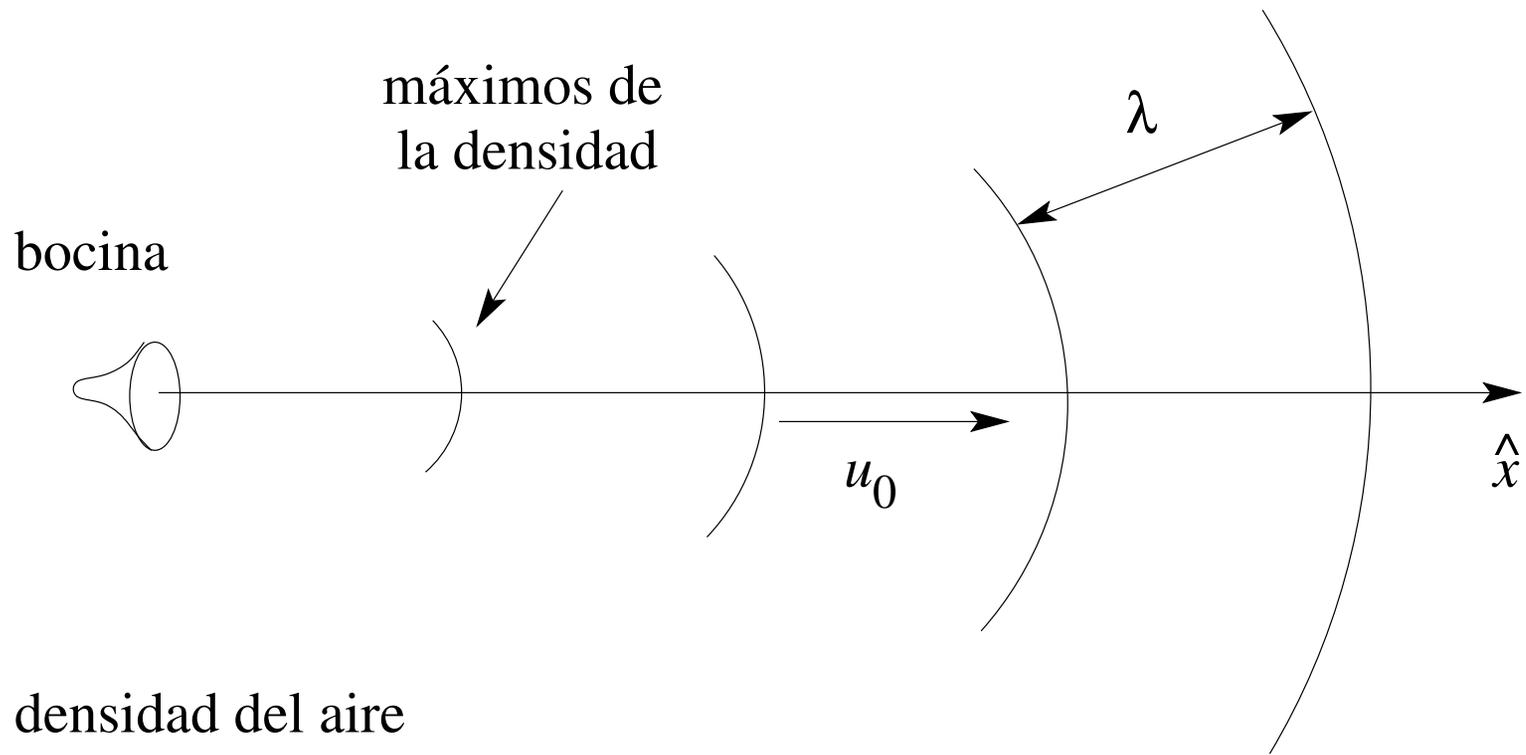
Transformaciones de Galileo



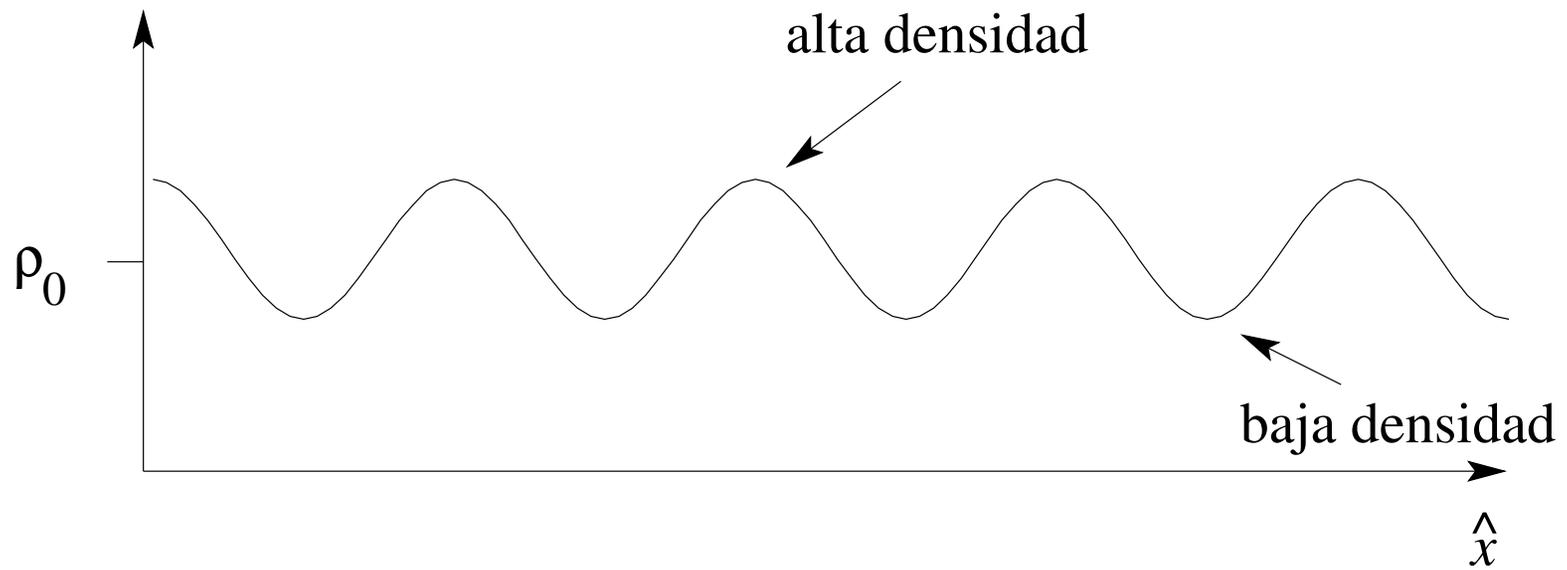
Composición de velocidades

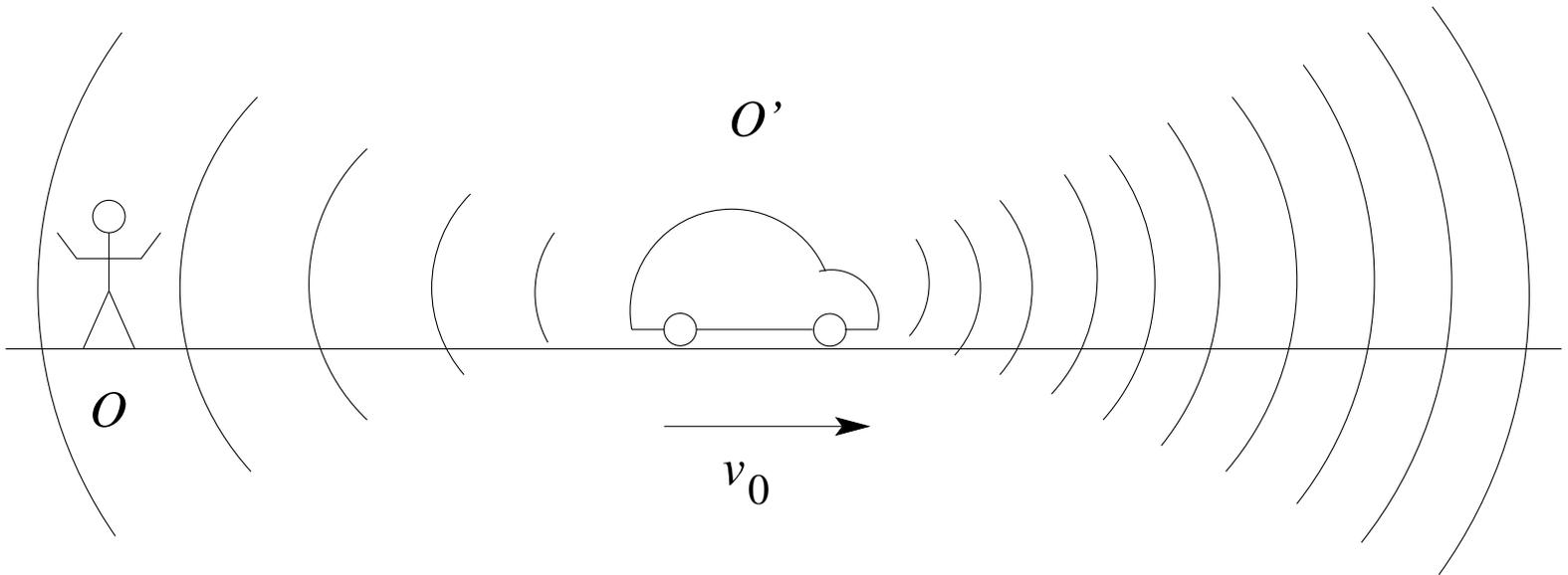


Pasado, presente y futuro del evento  $P$

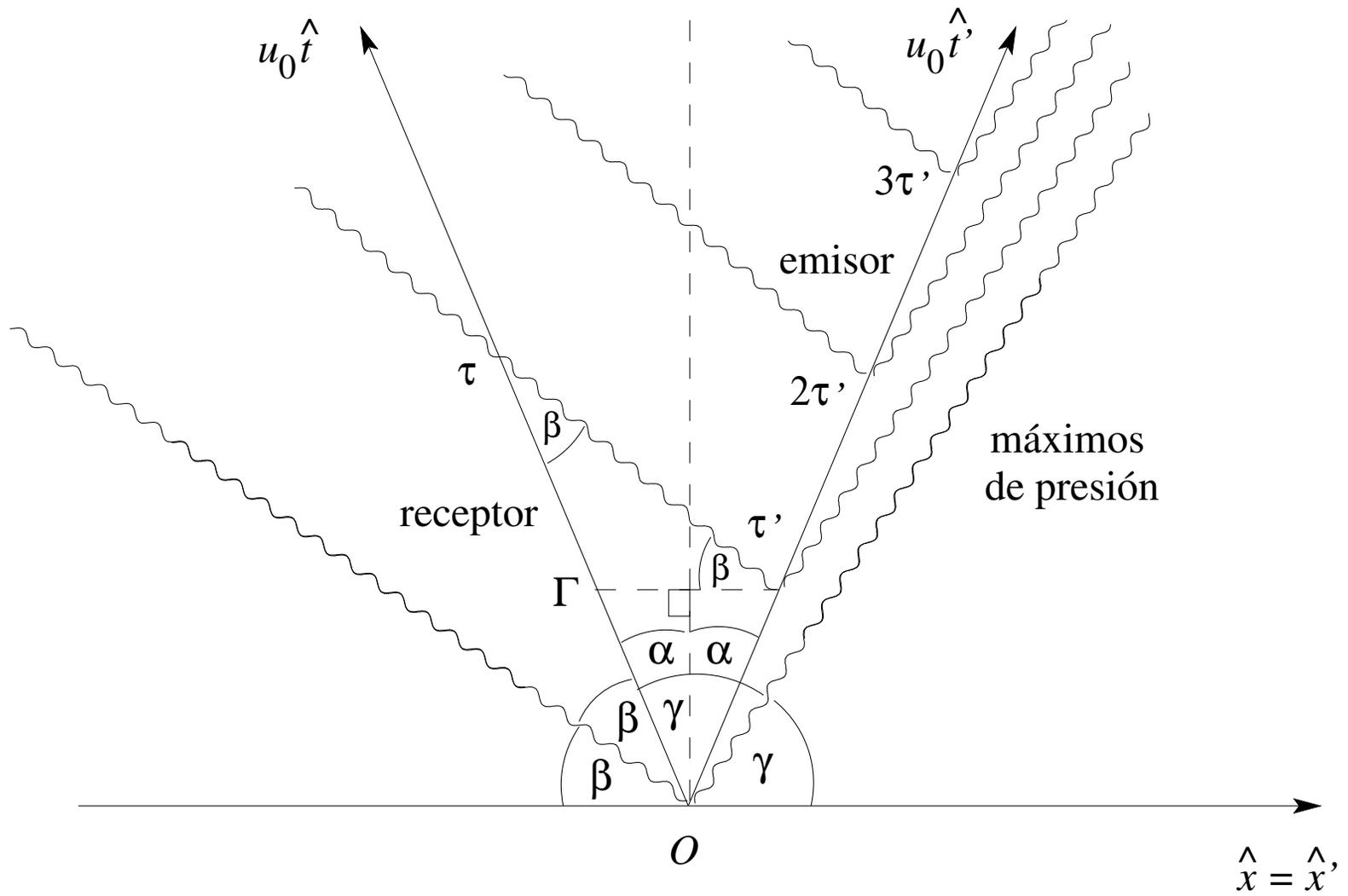


densidad del aire

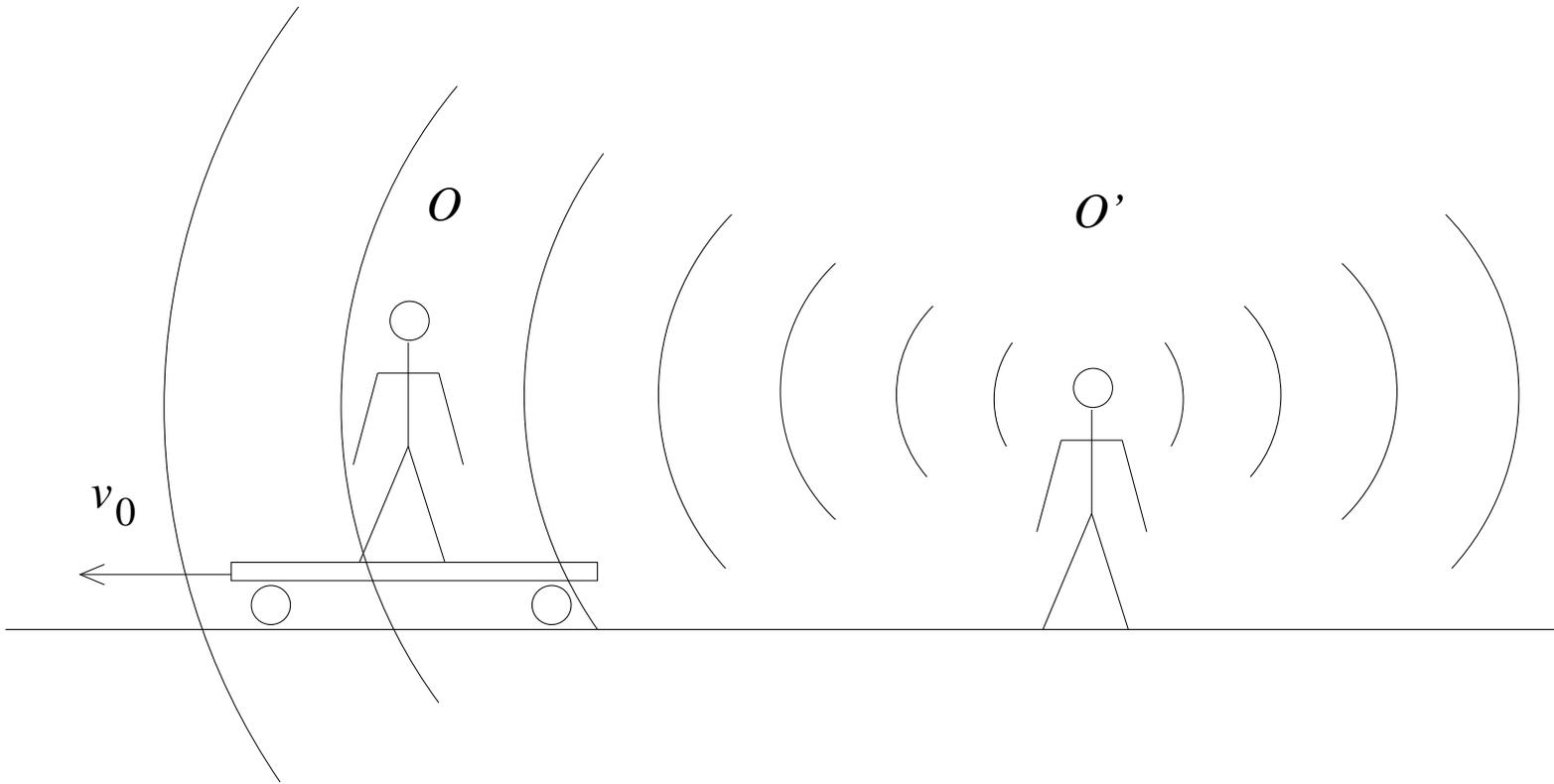




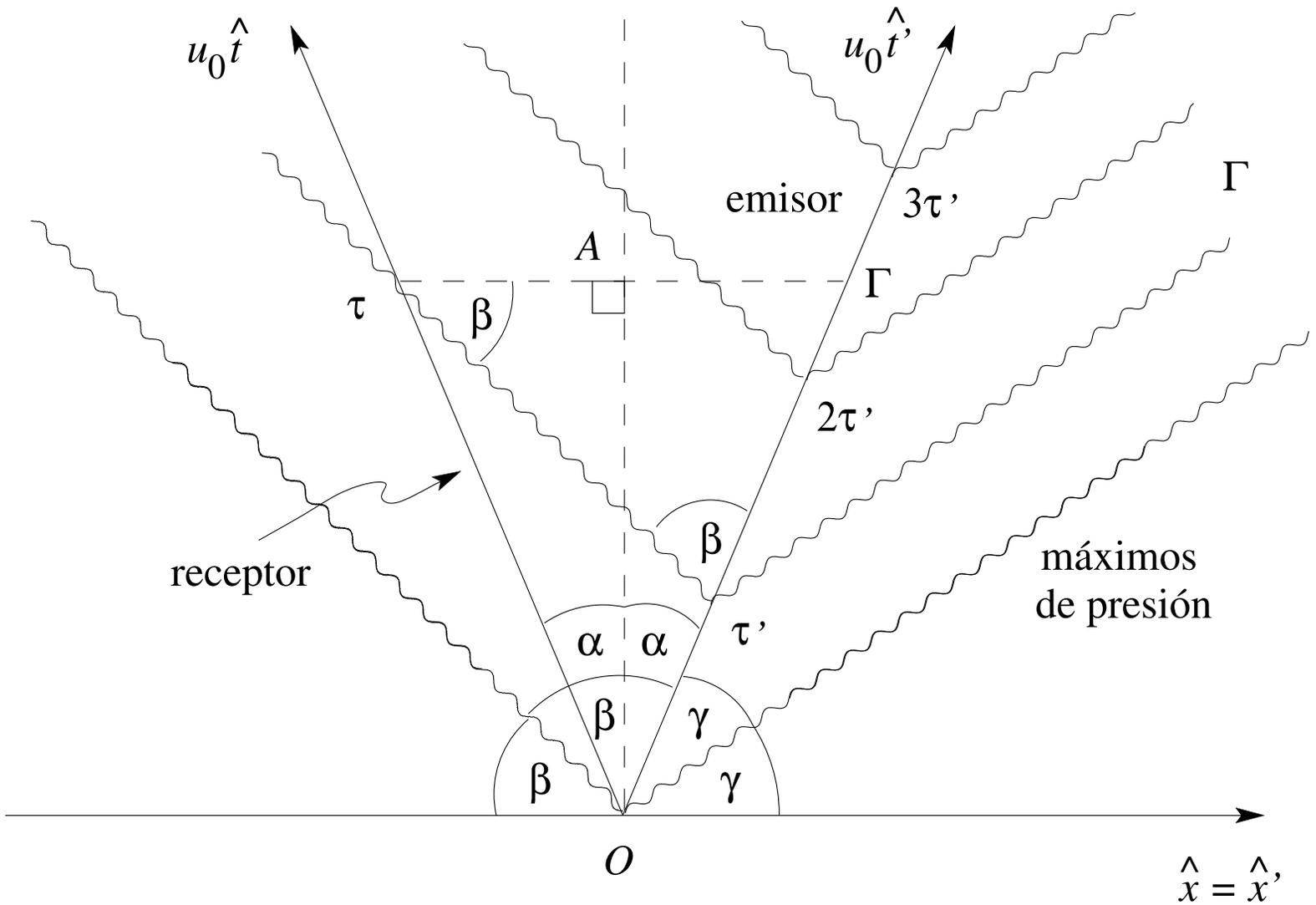
Efecto Doppler acústico: fuente en movimiento



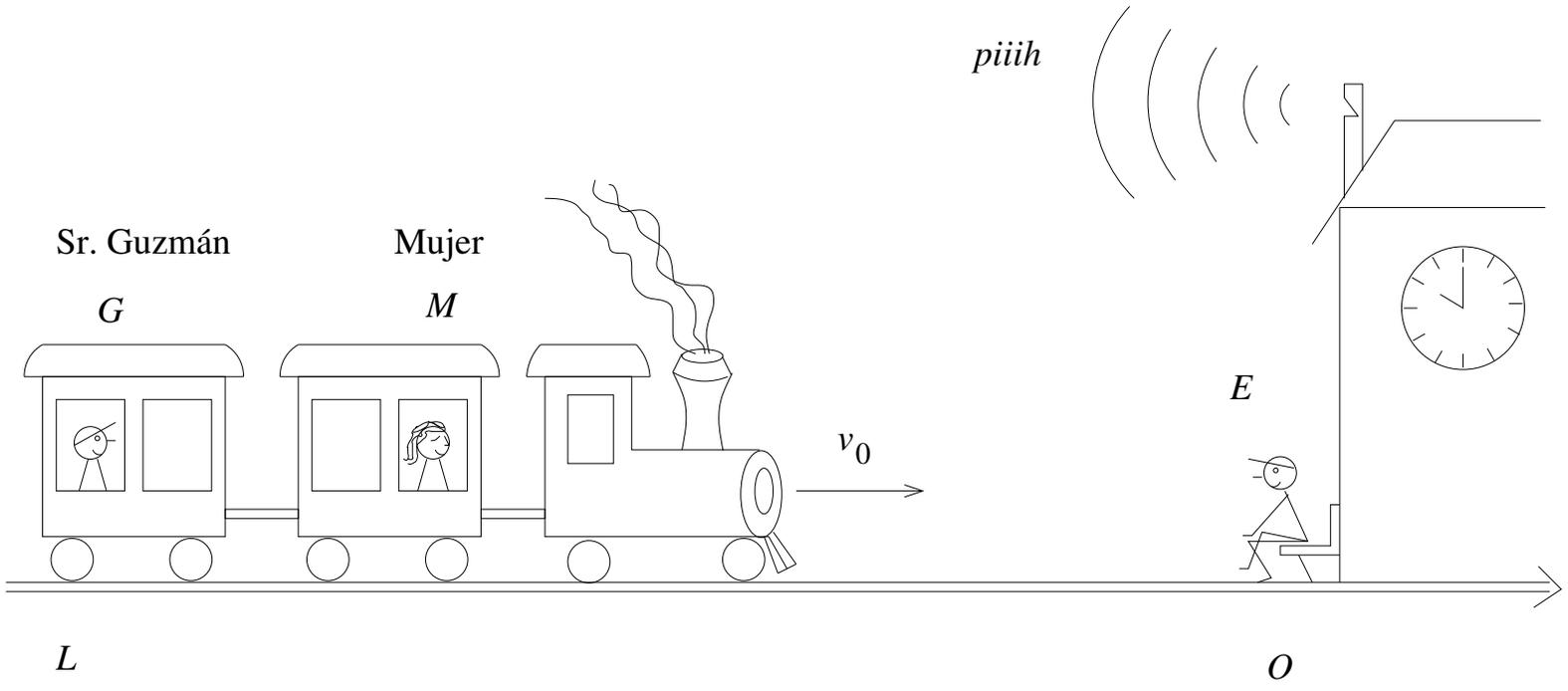
Efecto Doppler acústico: fuente en movimiento



Efecto Doppler acústico: fuente en reposo



Efecto Doppler acústico: fuente en reposo



El tren de los trágicos eventos

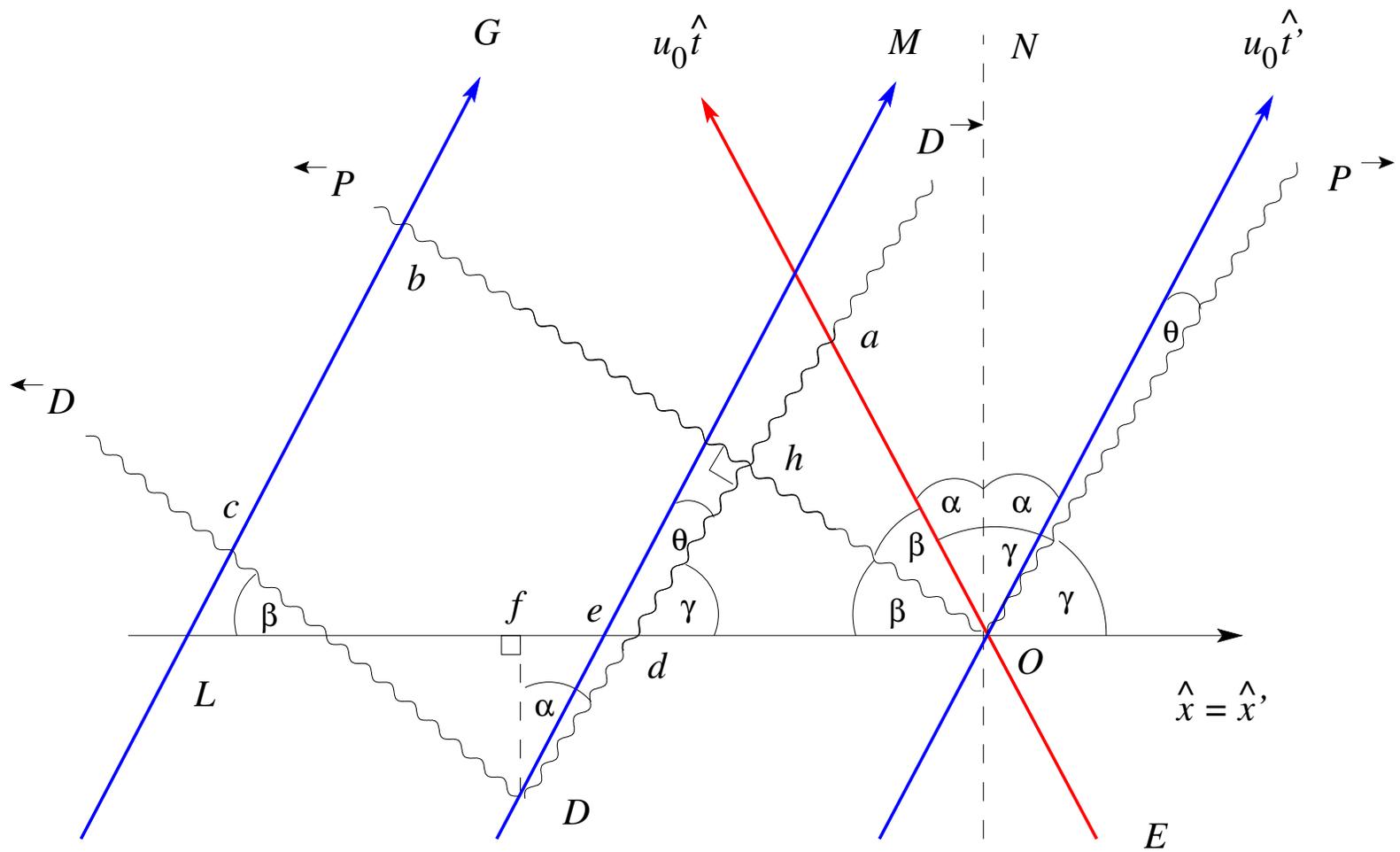
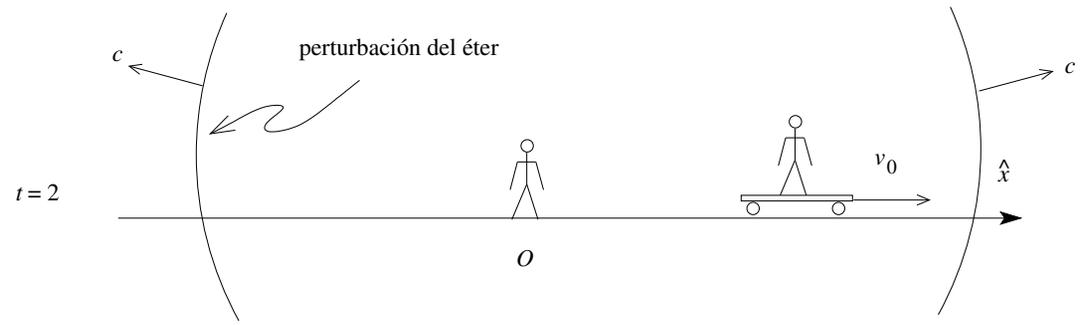
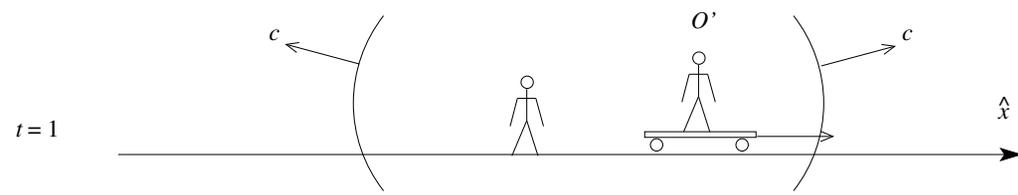
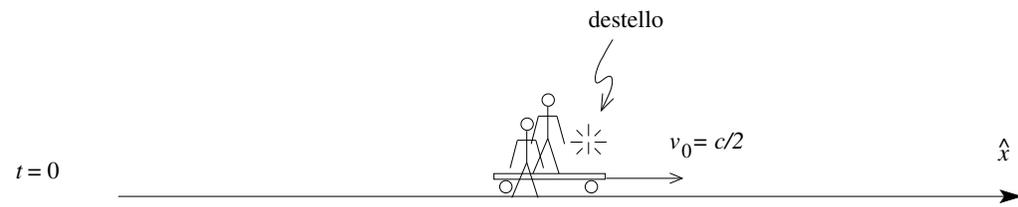
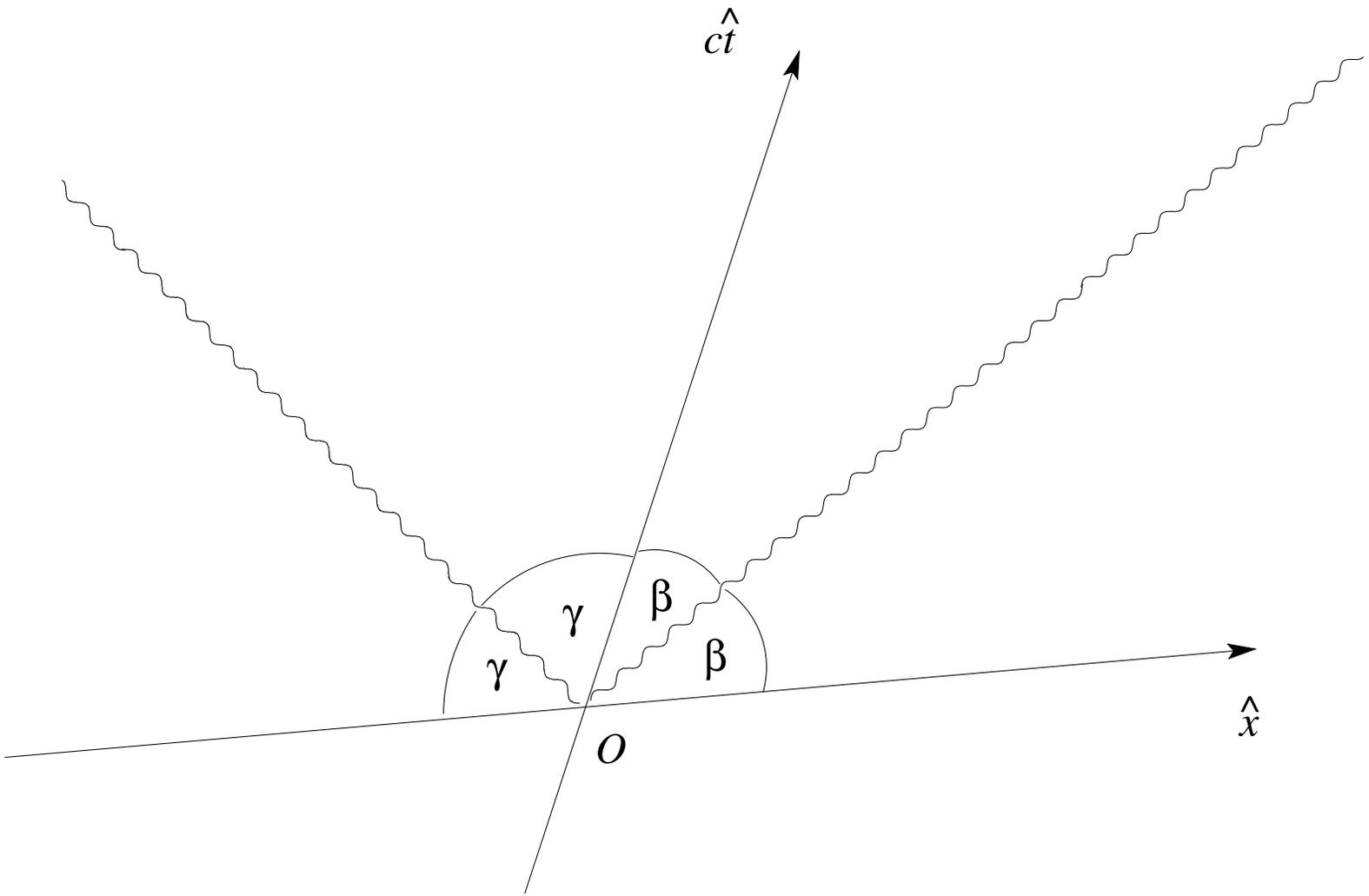


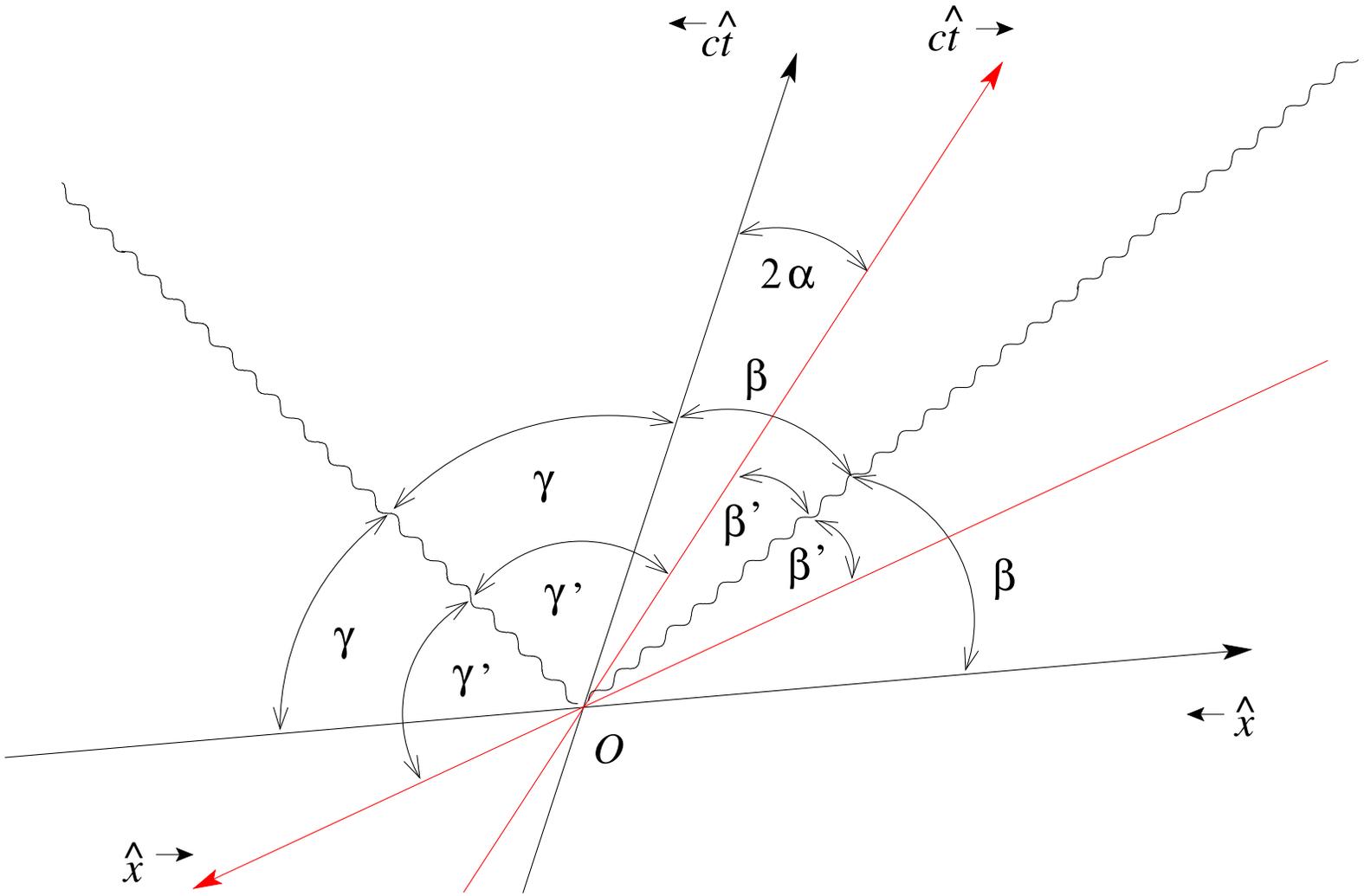
Diagrama espacio-tiempo para el tren de los trágicos eventos



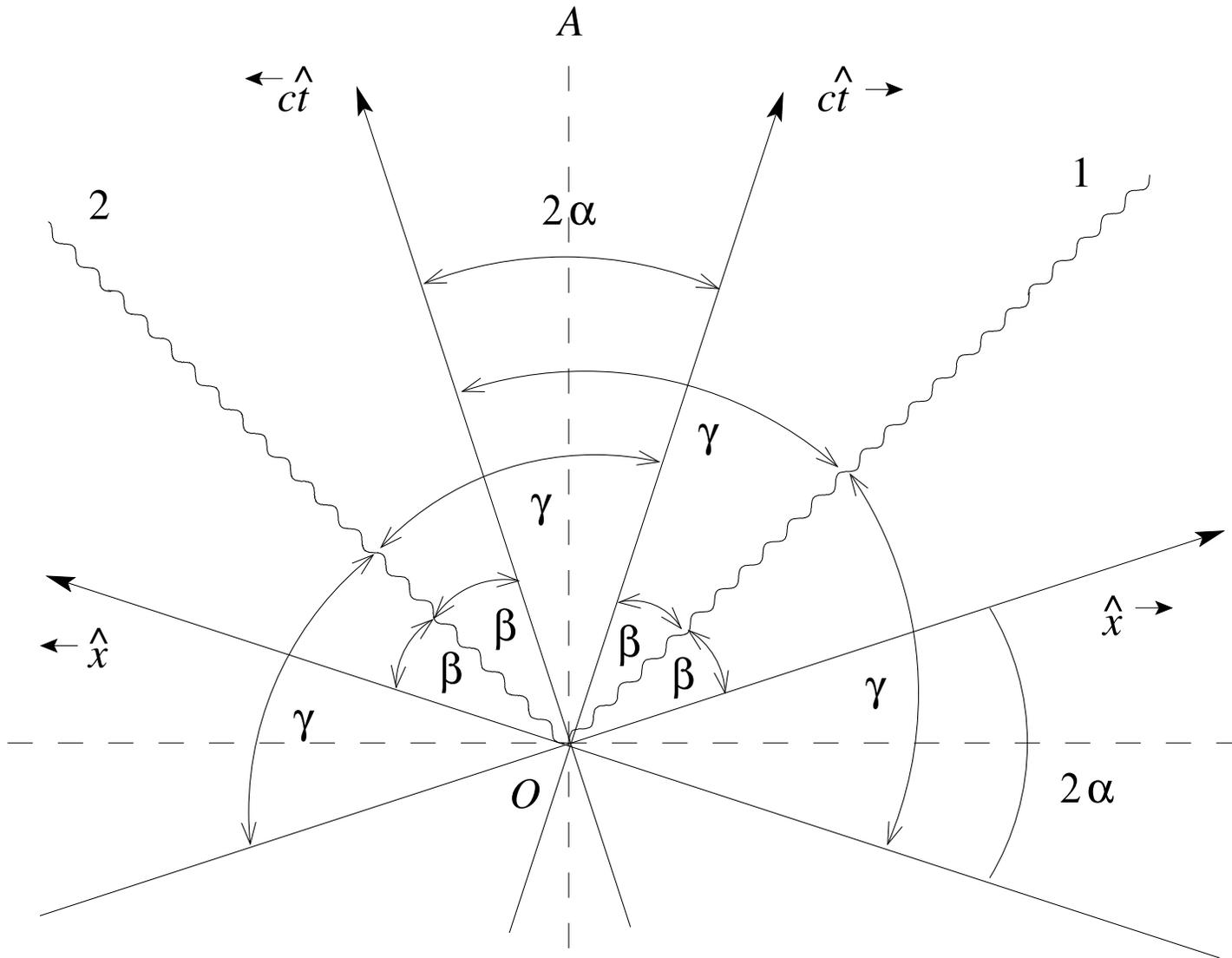
La luz como perturbación del éter



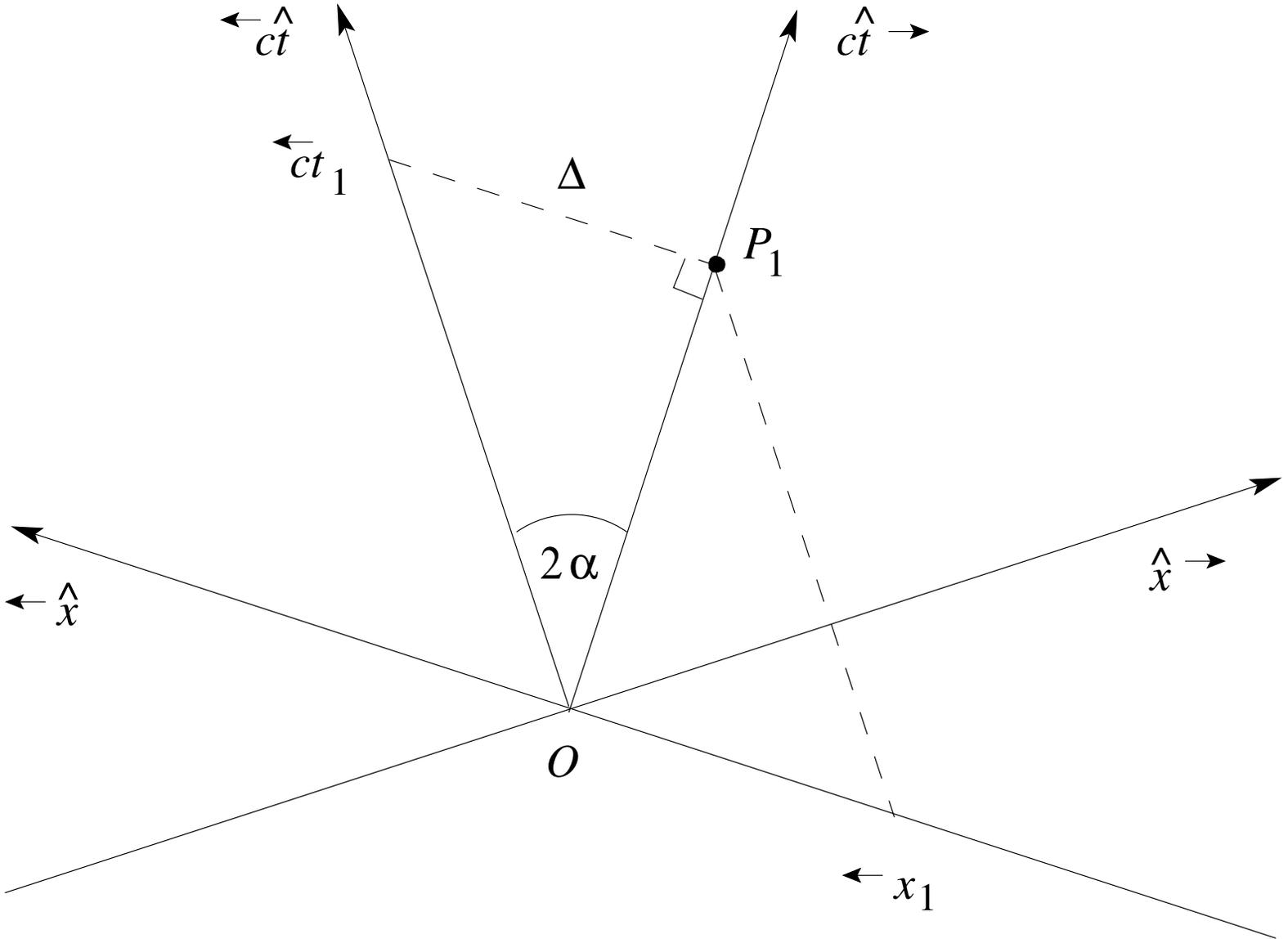
Líneas de vida de un destello



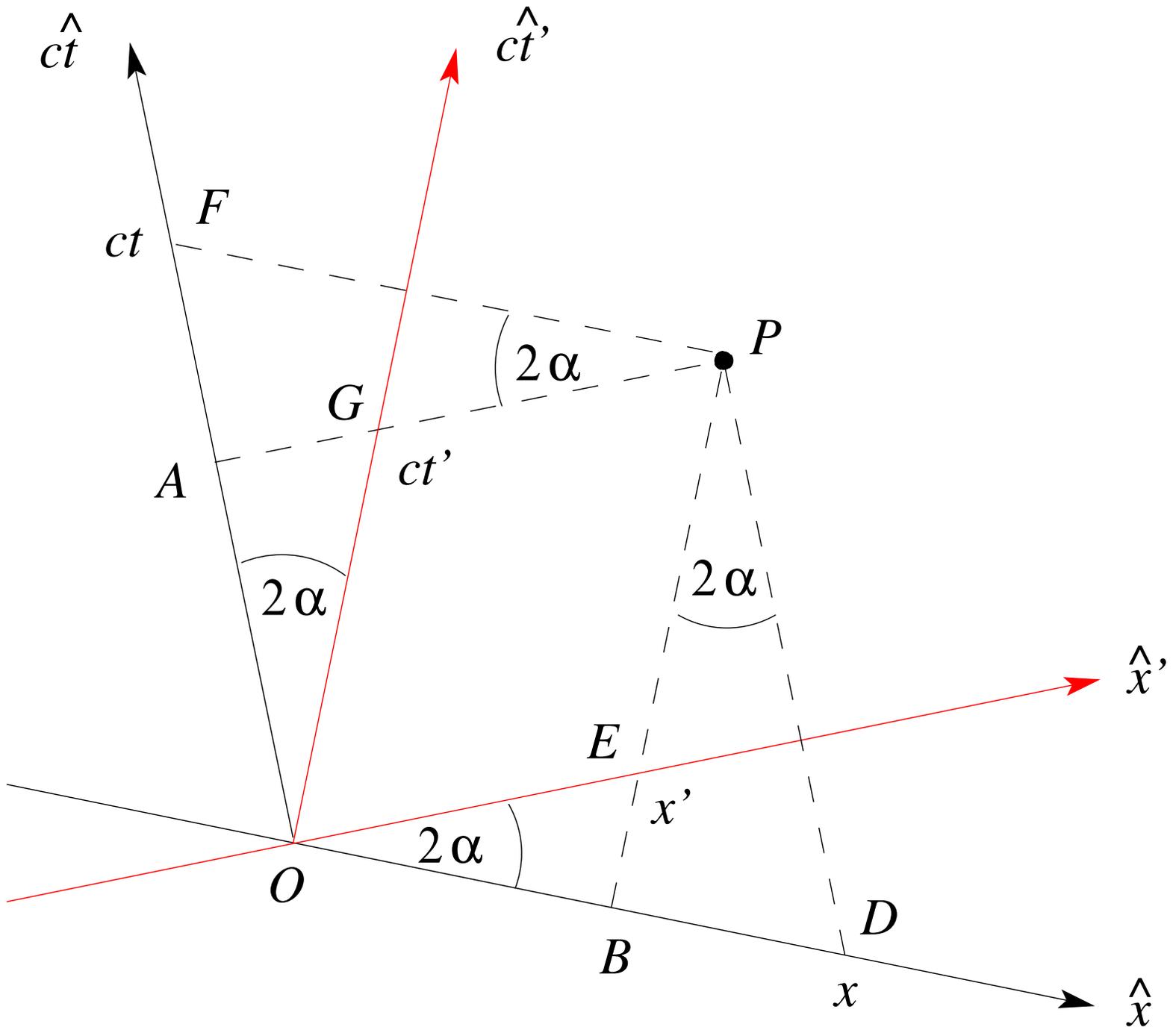
Referenciales espacio-temporales para dos observadores. Primera versión.

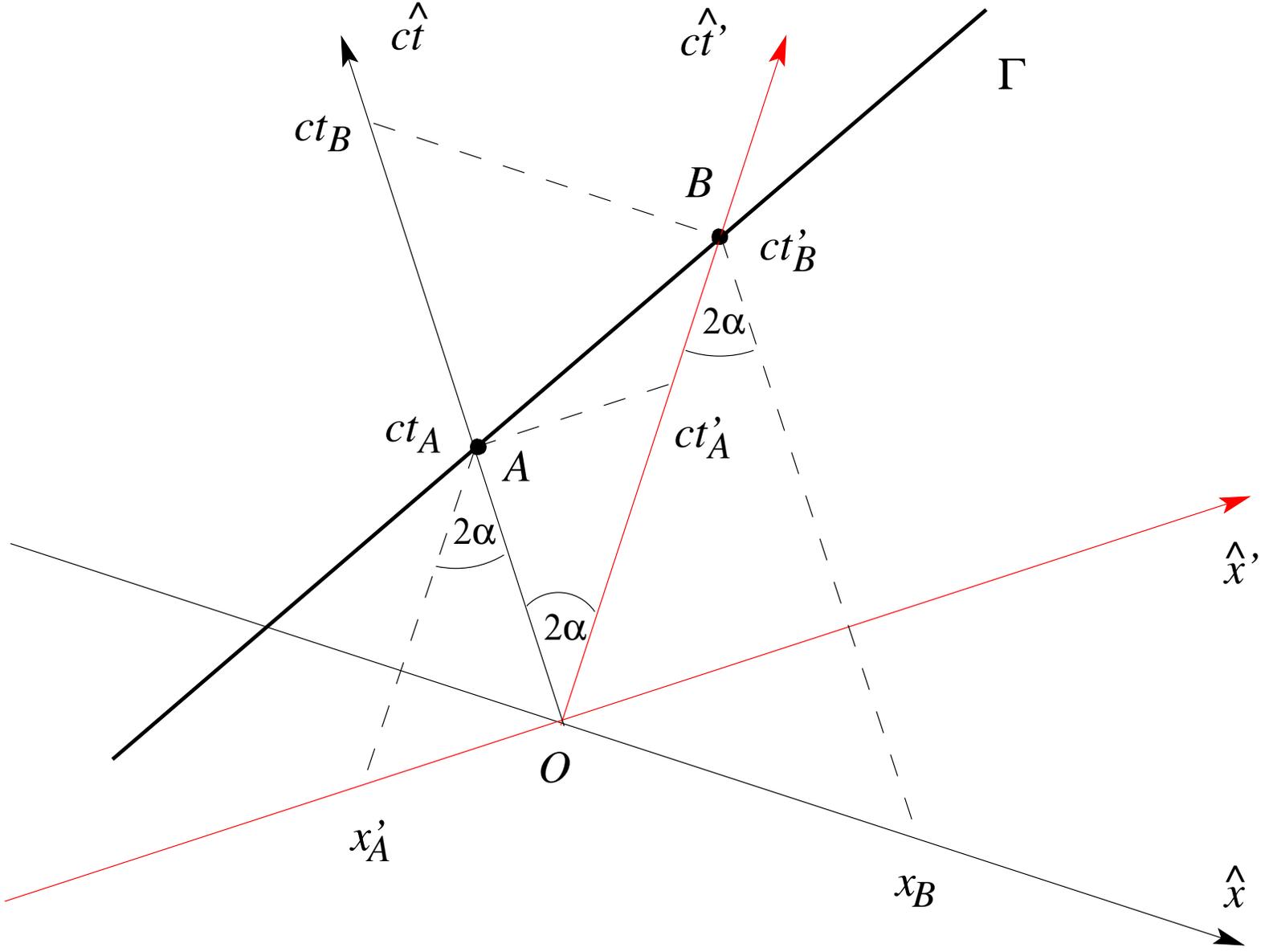


Referenciales espacio-temporales para dos observadores. Segunda versión.

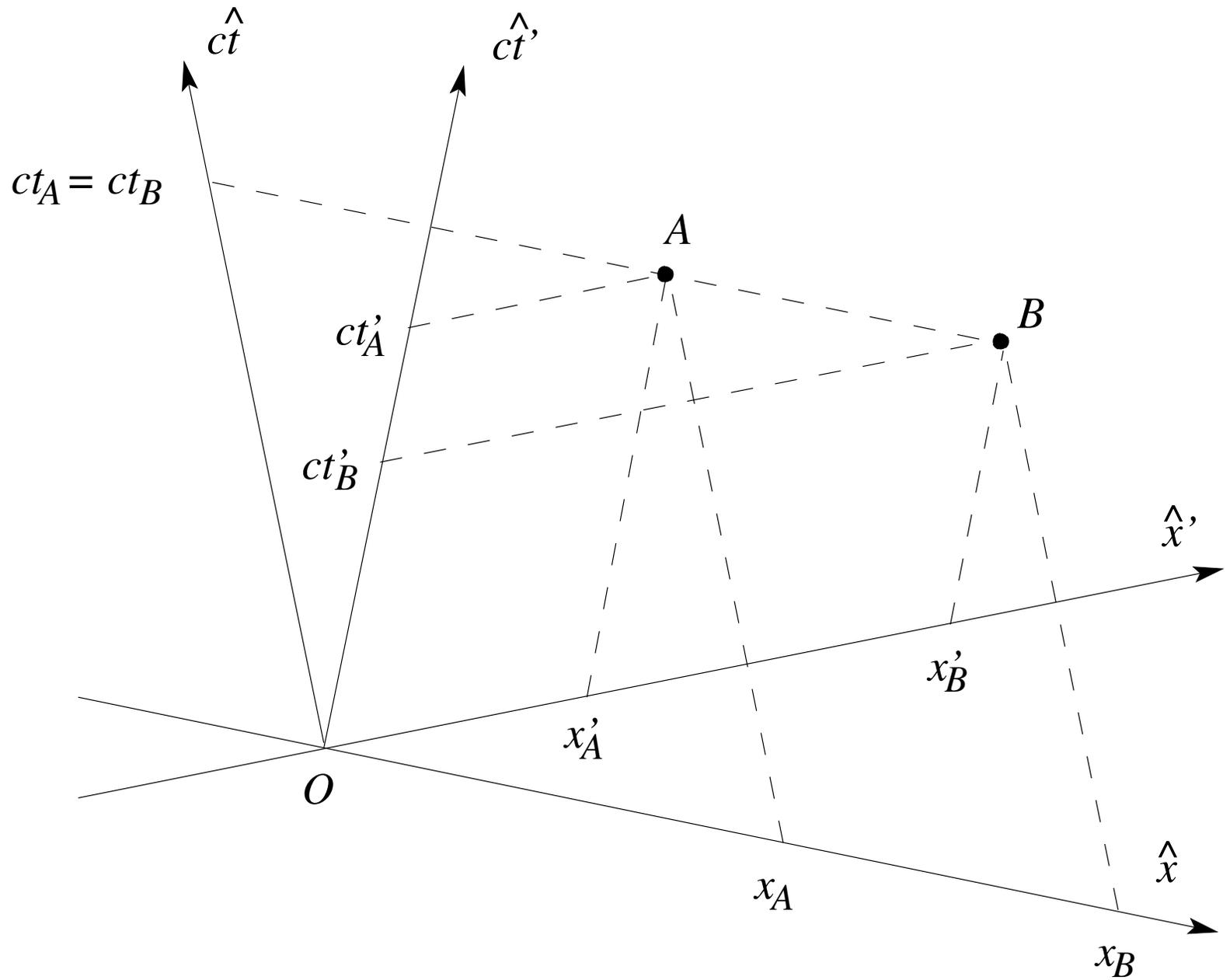


Relación entre ángulo  $\alpha$  y velocidad relativa  $v_0$

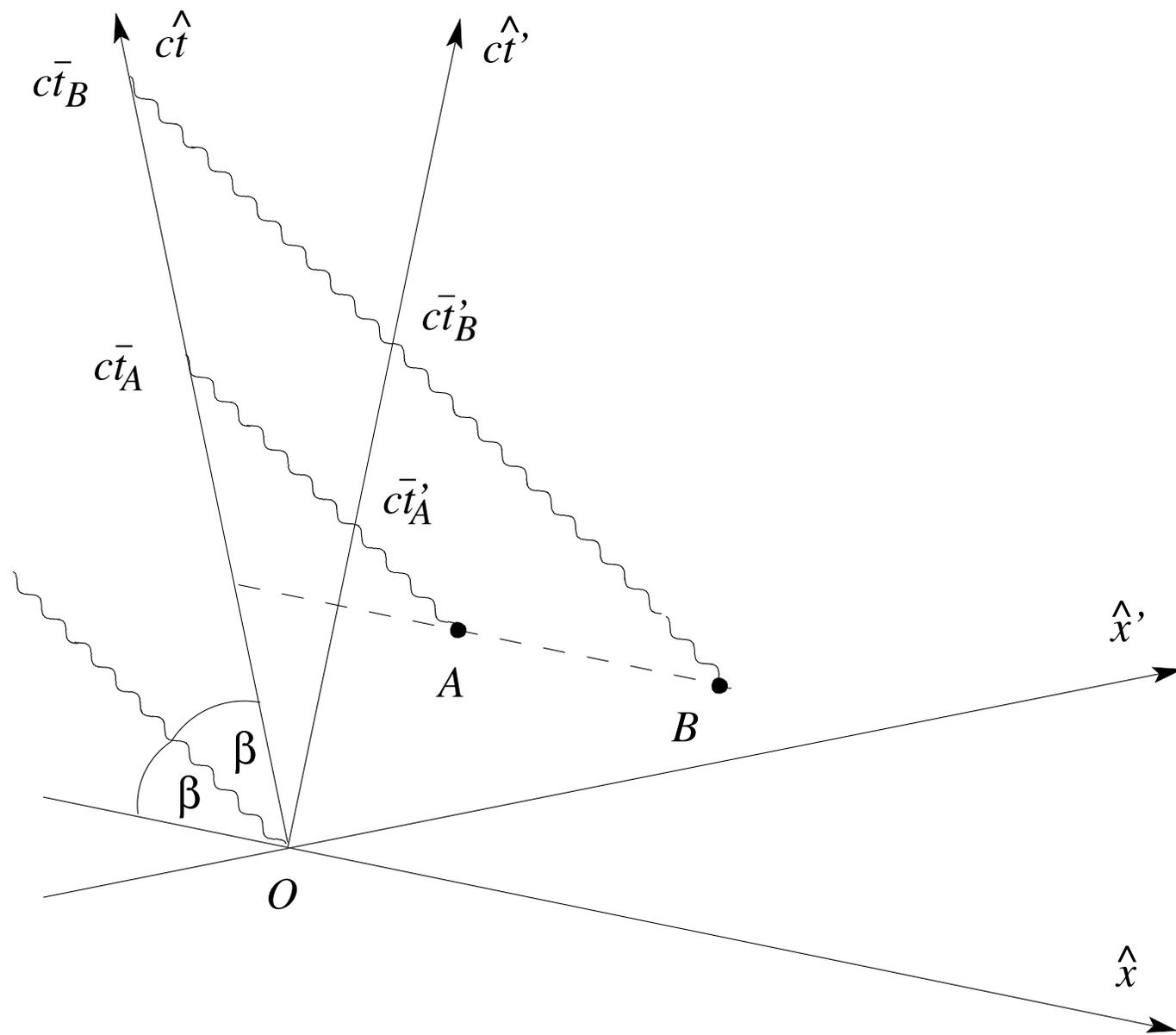




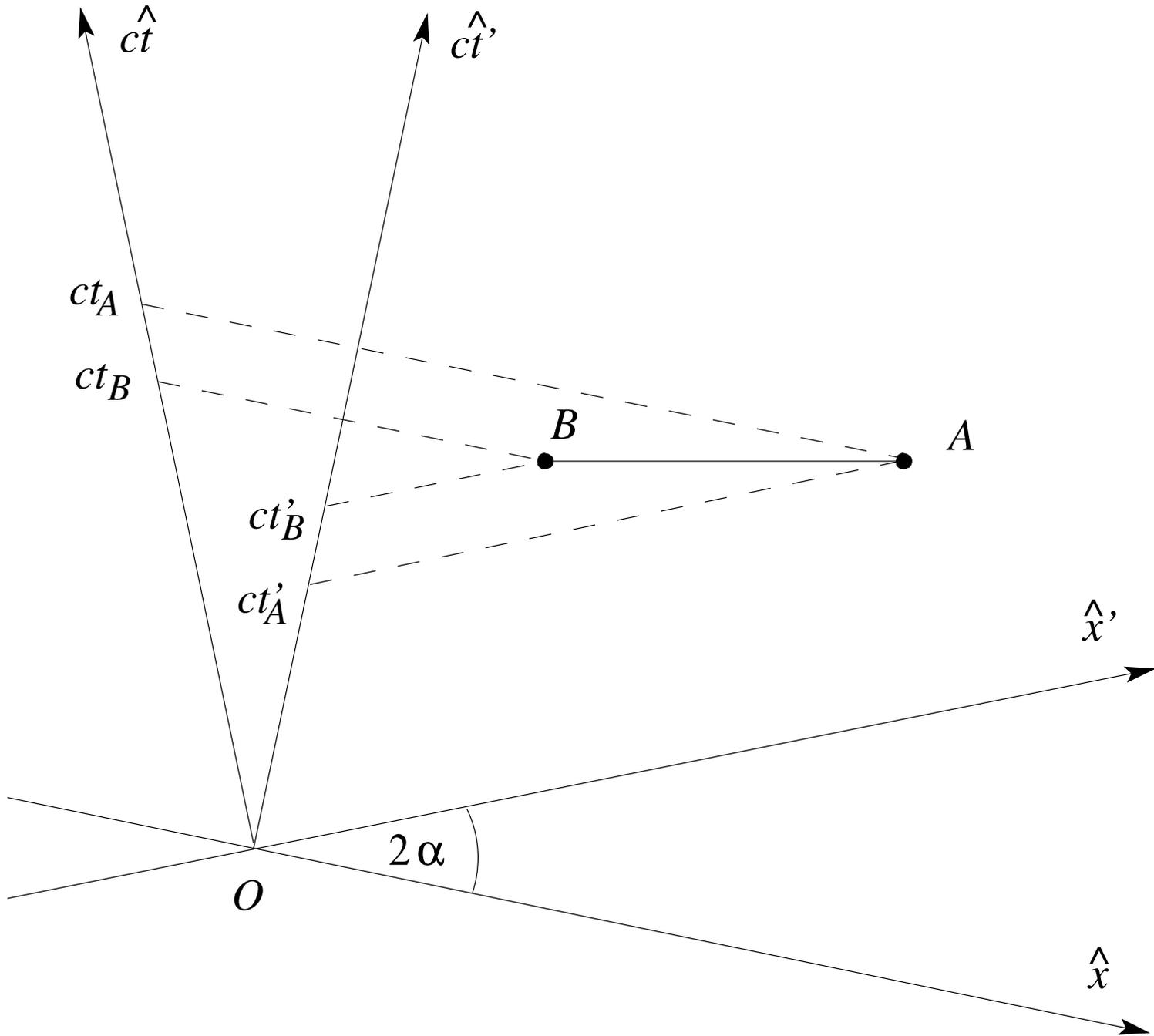
Composición de velocidades



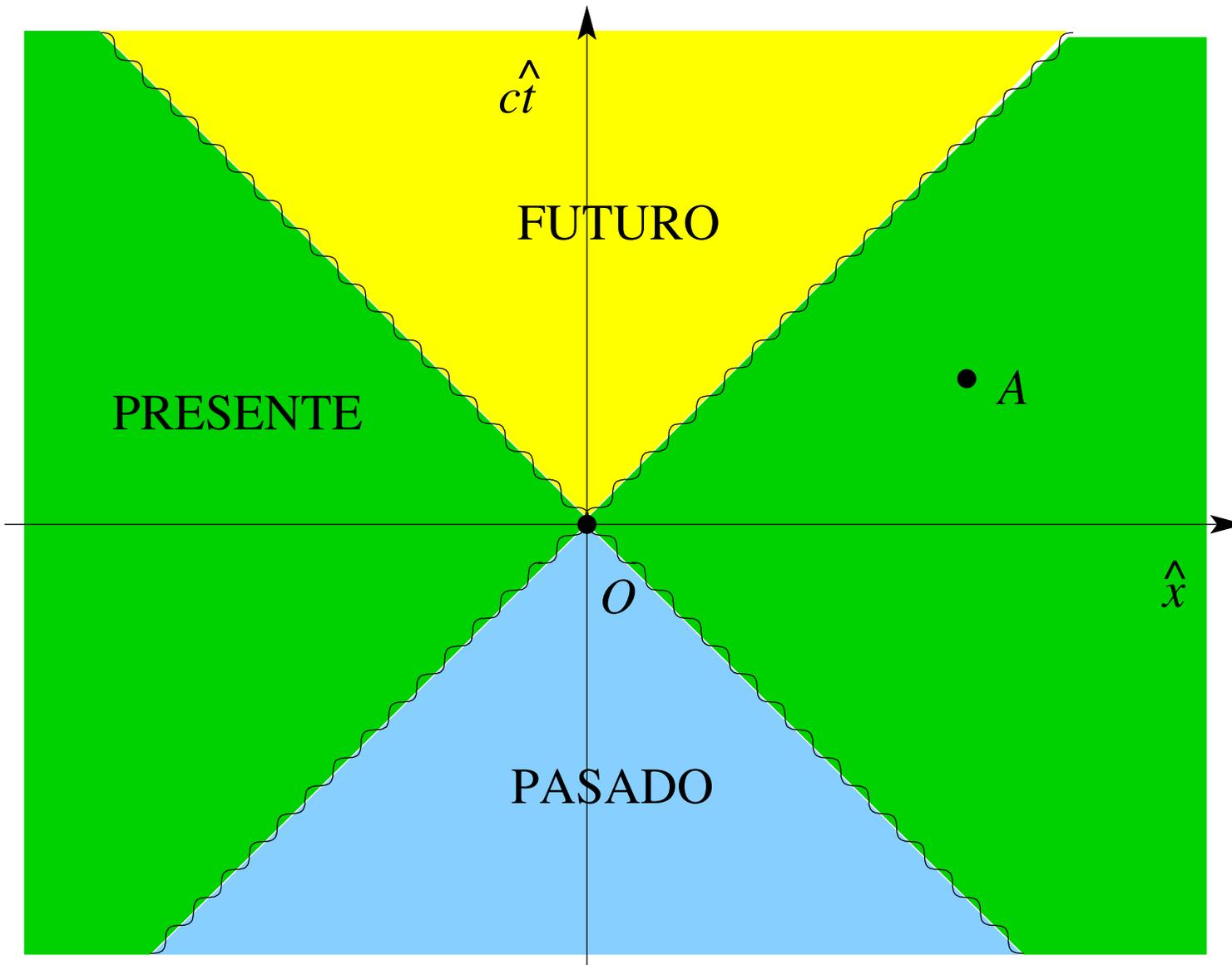
Dos eventos simultáneos para un observador



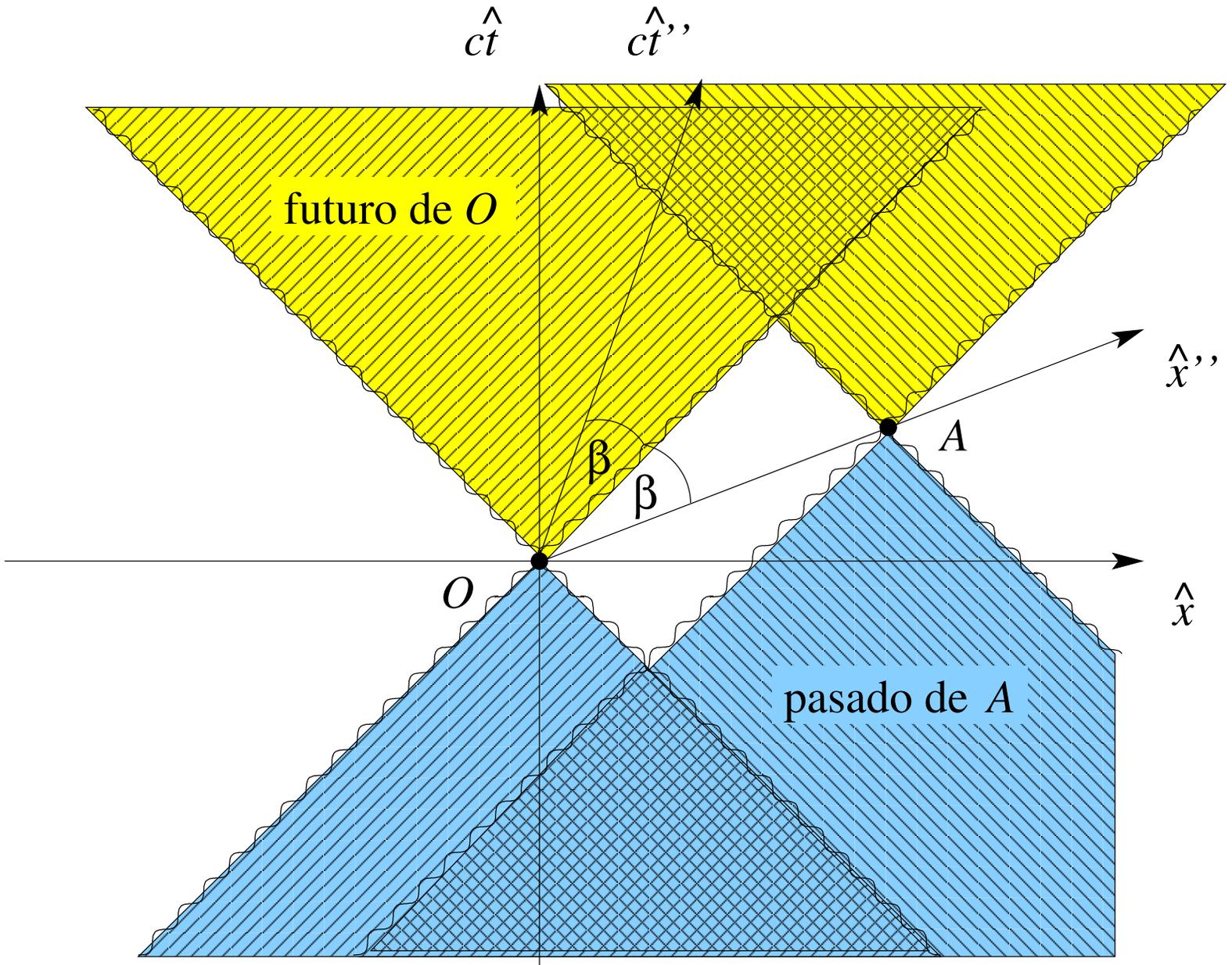
Dos eventos simultáneos para un observador. Destellos emitidos.



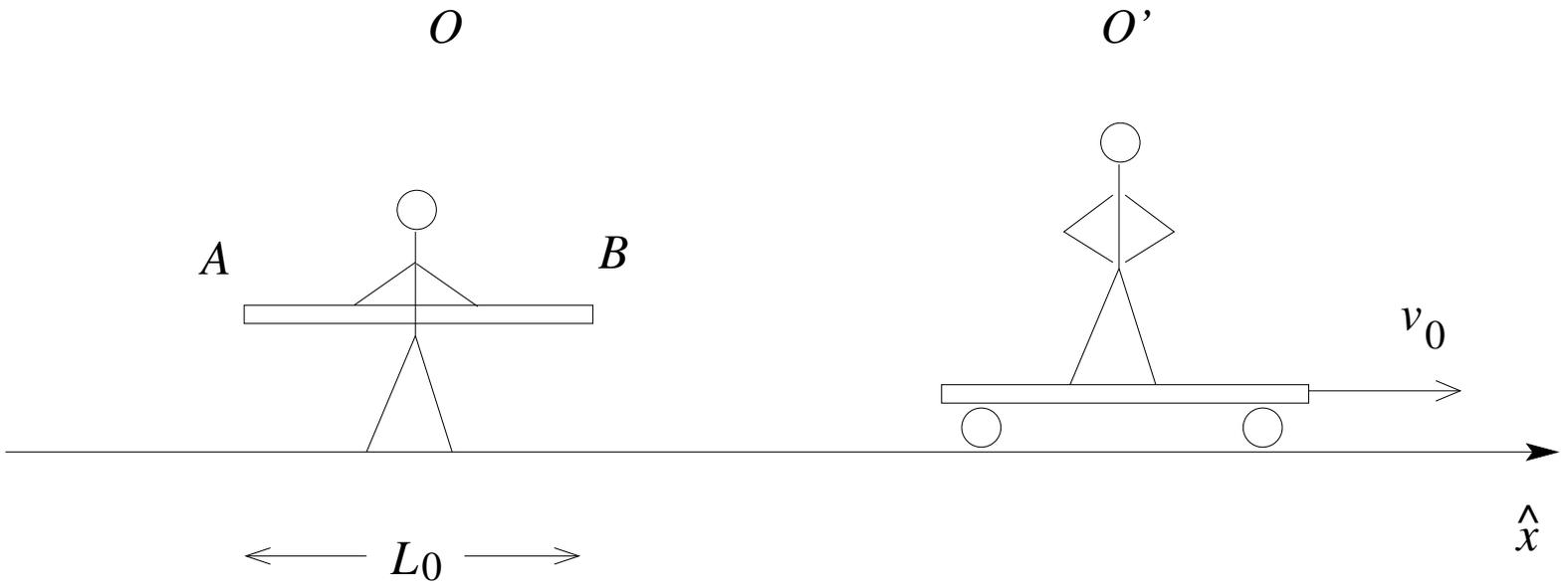
Dos eventos no conectados causalmente



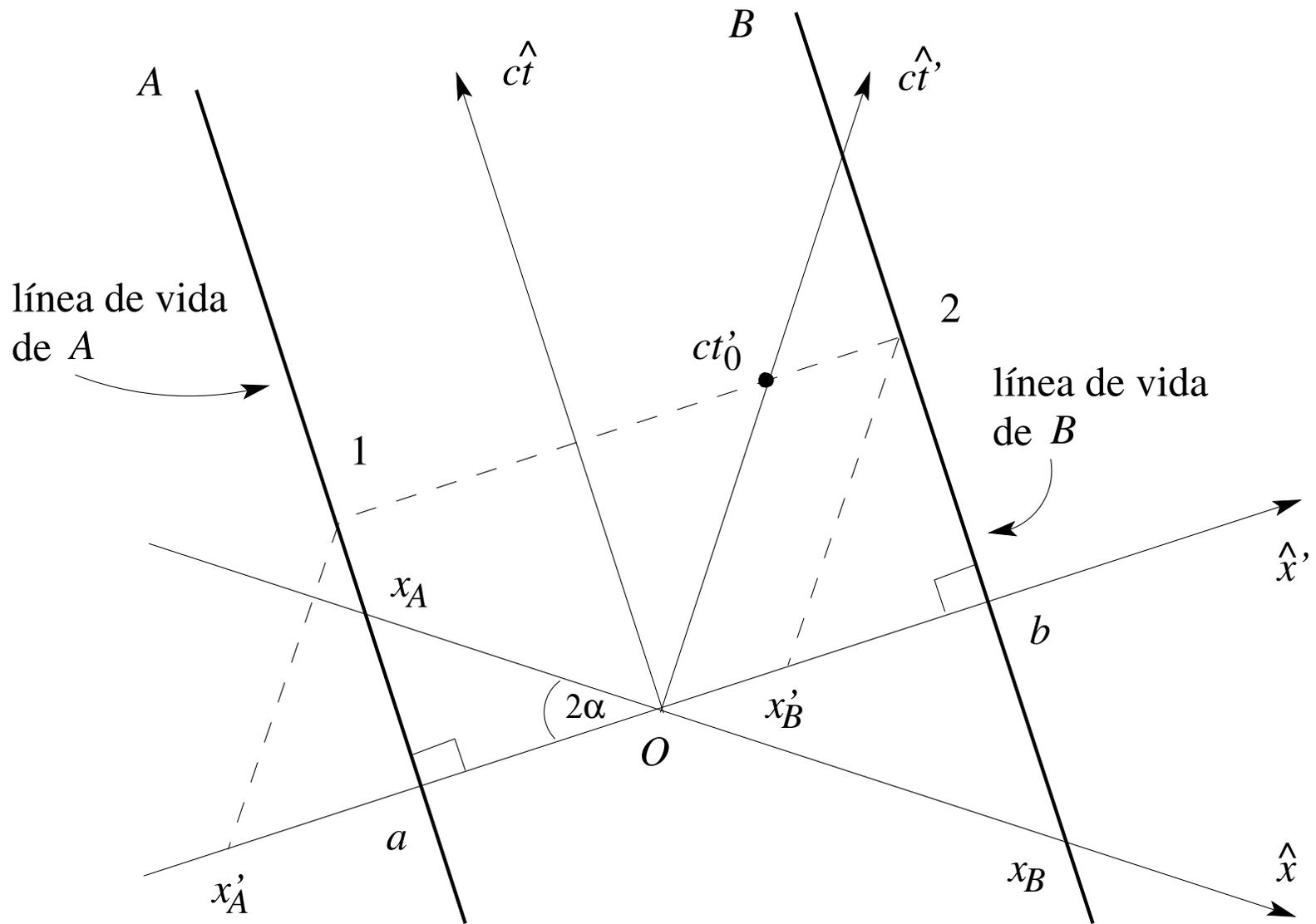
Pasado, presente y futuro del evento  $O$  en relatividad especial



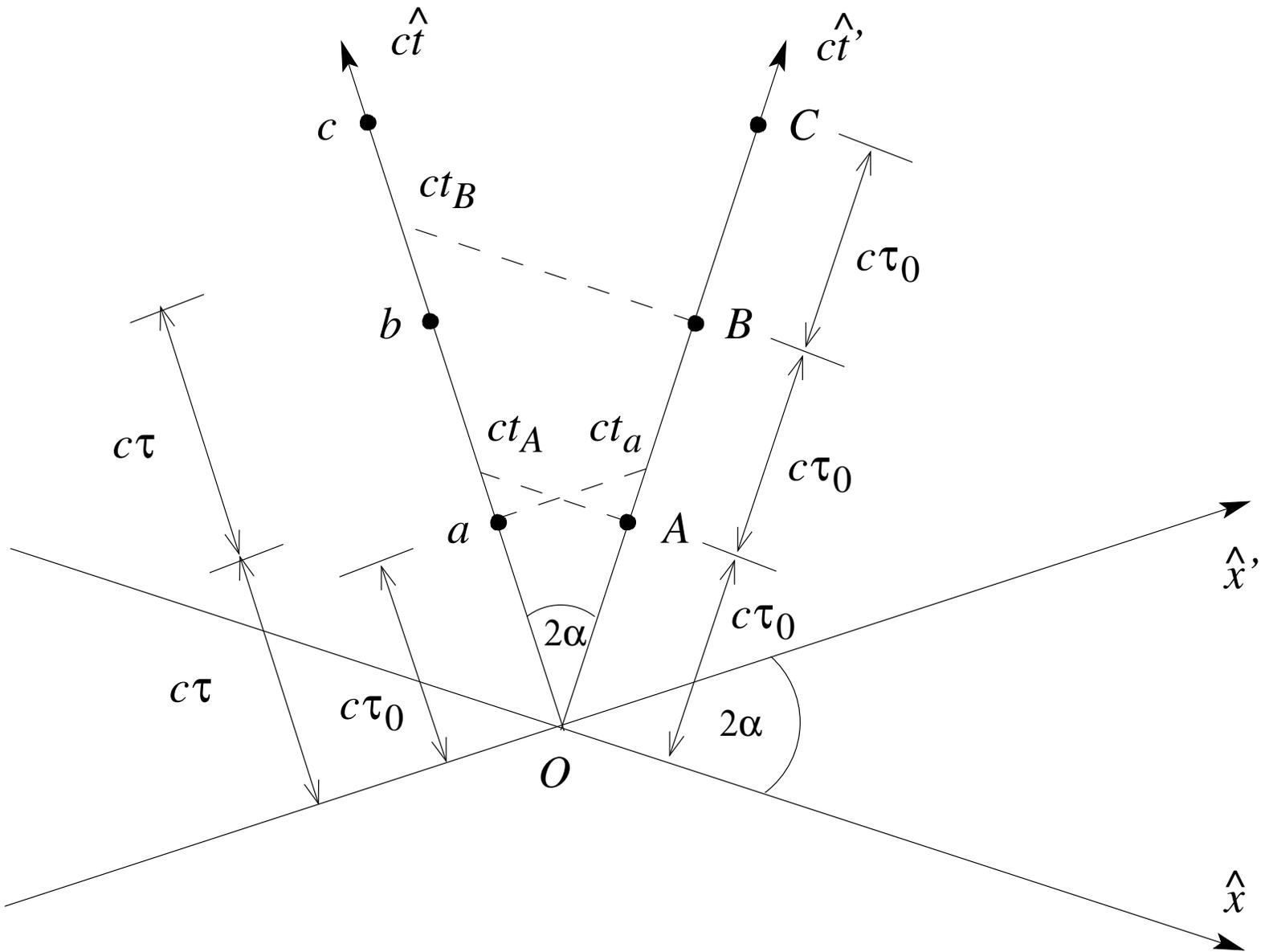
Dos eventos, uno en el presente del otro.



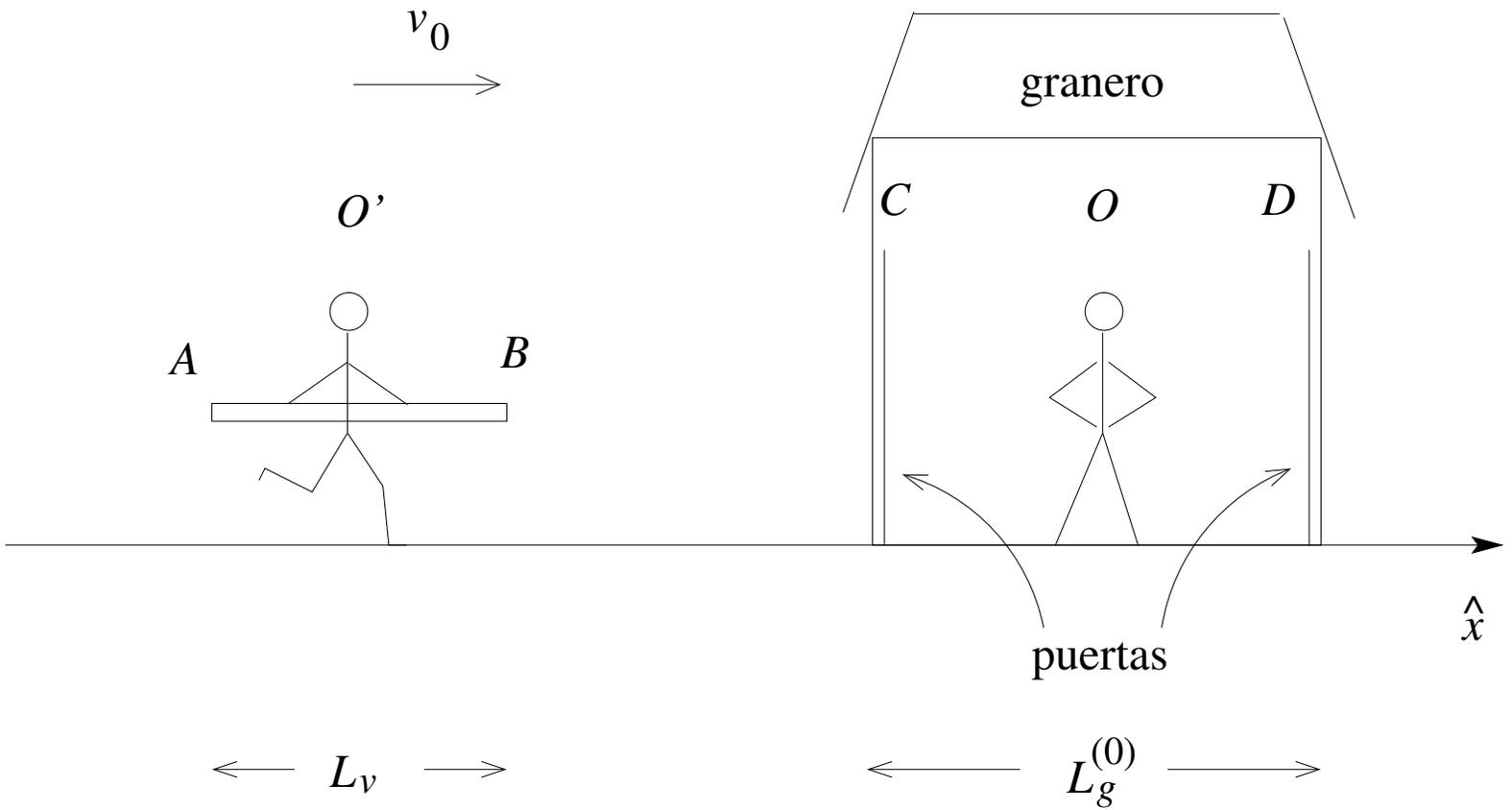
Contracción de Lorentz. Dos observadores en movimiento relativo.



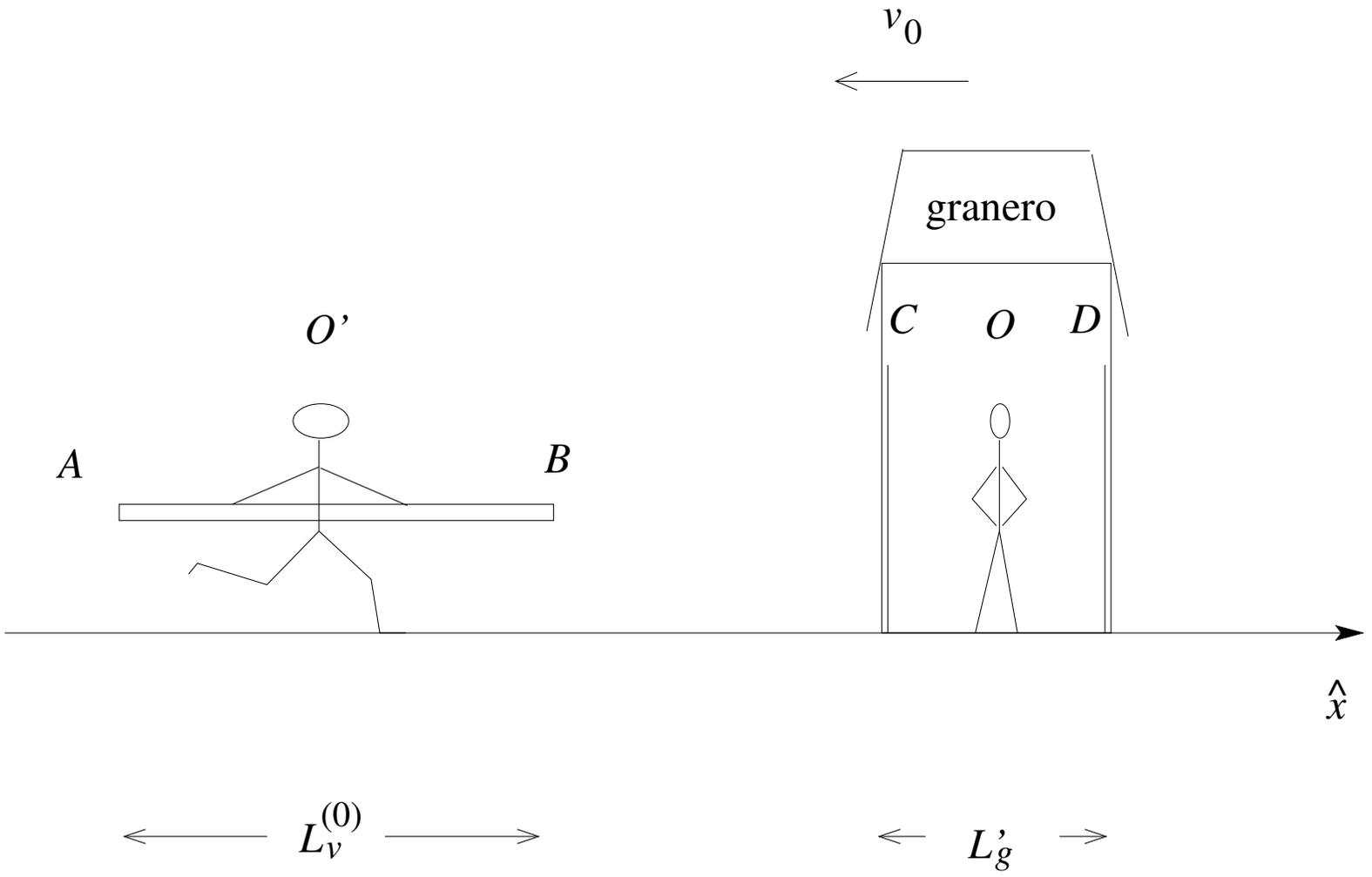
Contracción de Lorentz. Diagrama.



Dilatación del tiempo



La paradoja del granero. Situación para el observador  $O$ .



La paradoja del granero. Situación para el observador  $O'$

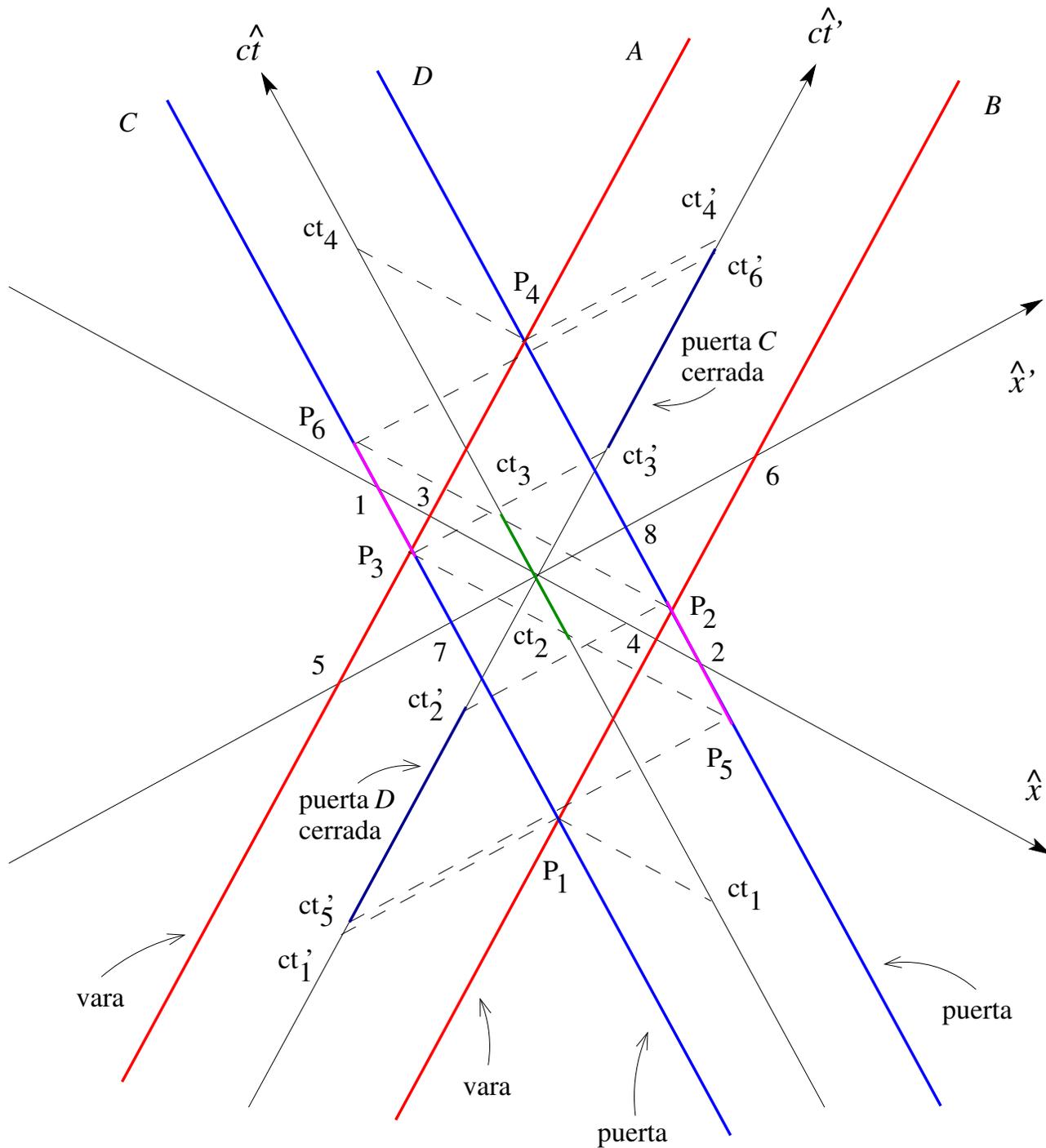
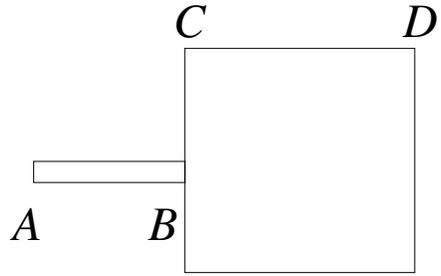
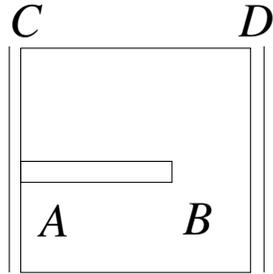


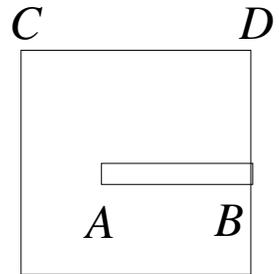
Diagrama espacio-tiempo para la paradoja del granero



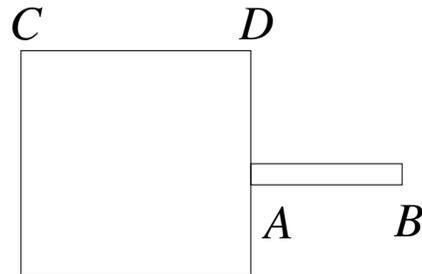
evento  $P_1$ : -  $B$  llega a  $C$   
 $t = t_1$



evento  $P_3$ : -  $A$  llega a  $C$   
 -  $C$  se cierra  
 evento  $P_5$ : -  $D$  se cierra  
 $t = t_2$

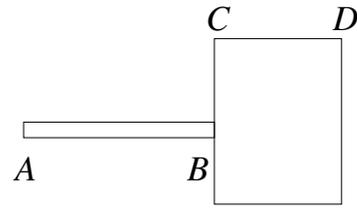


evento  $P_2$ : -  $B$  llega a  $D$   
 -  $D$  se abre  
 evento  $P_6$ : -  $C$  se abre  
 $t = t_3$

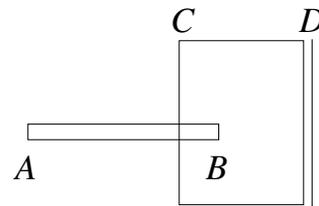


evento  $P_4$ : -  $A$  llega a  $D$   
 $t = t_4$

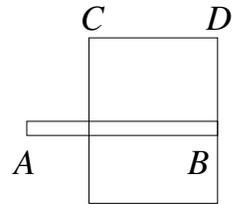
Sucesión de eventos para el observador  $O$



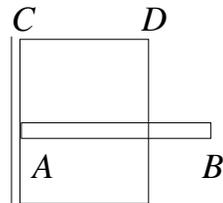
evento  $P_1$ : -  $B$  llega a  $C$   
 $t' = t'_1$



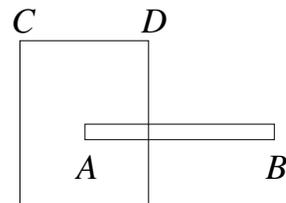
evento  $P_5$ : -  $D$  se cierra  
 $t' = t'_5$



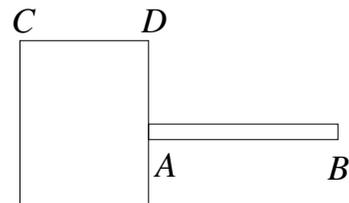
evento  $P_2$ : -  $D$  se abre  
 $t' = t'_2$



evento  $P_3$ : -  $A$  llega a  $C$   
 -  $C$  se cierra  
 $t' = t'_3$



evento  $P_6$ : -  $C$  se abre  
 $t' = t'_6$



evento  $P_4$ : -  $A$  llega a  $D$   
 $t' = t'_4$

Sucesión de eventos para el observador  $Q'$

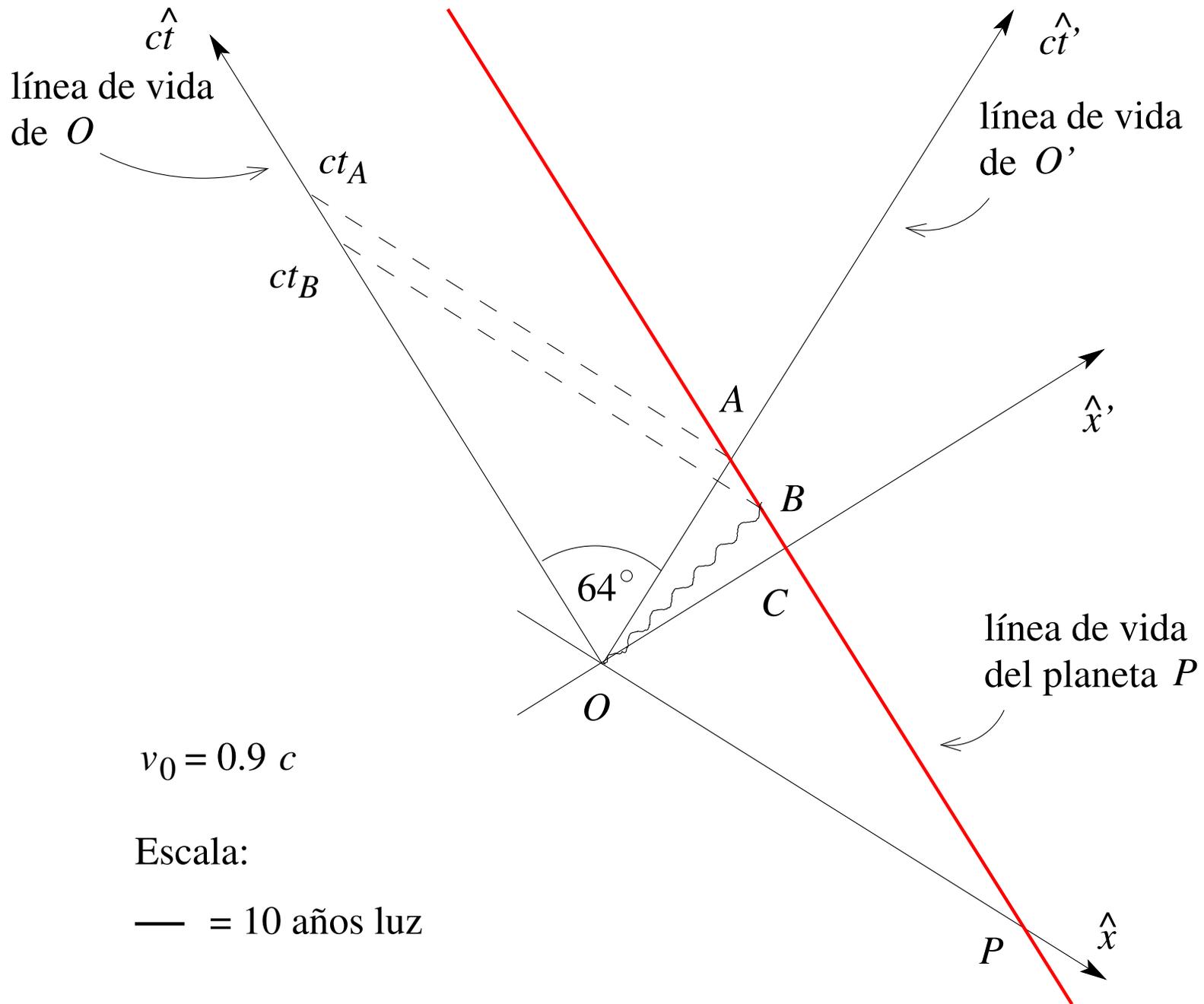
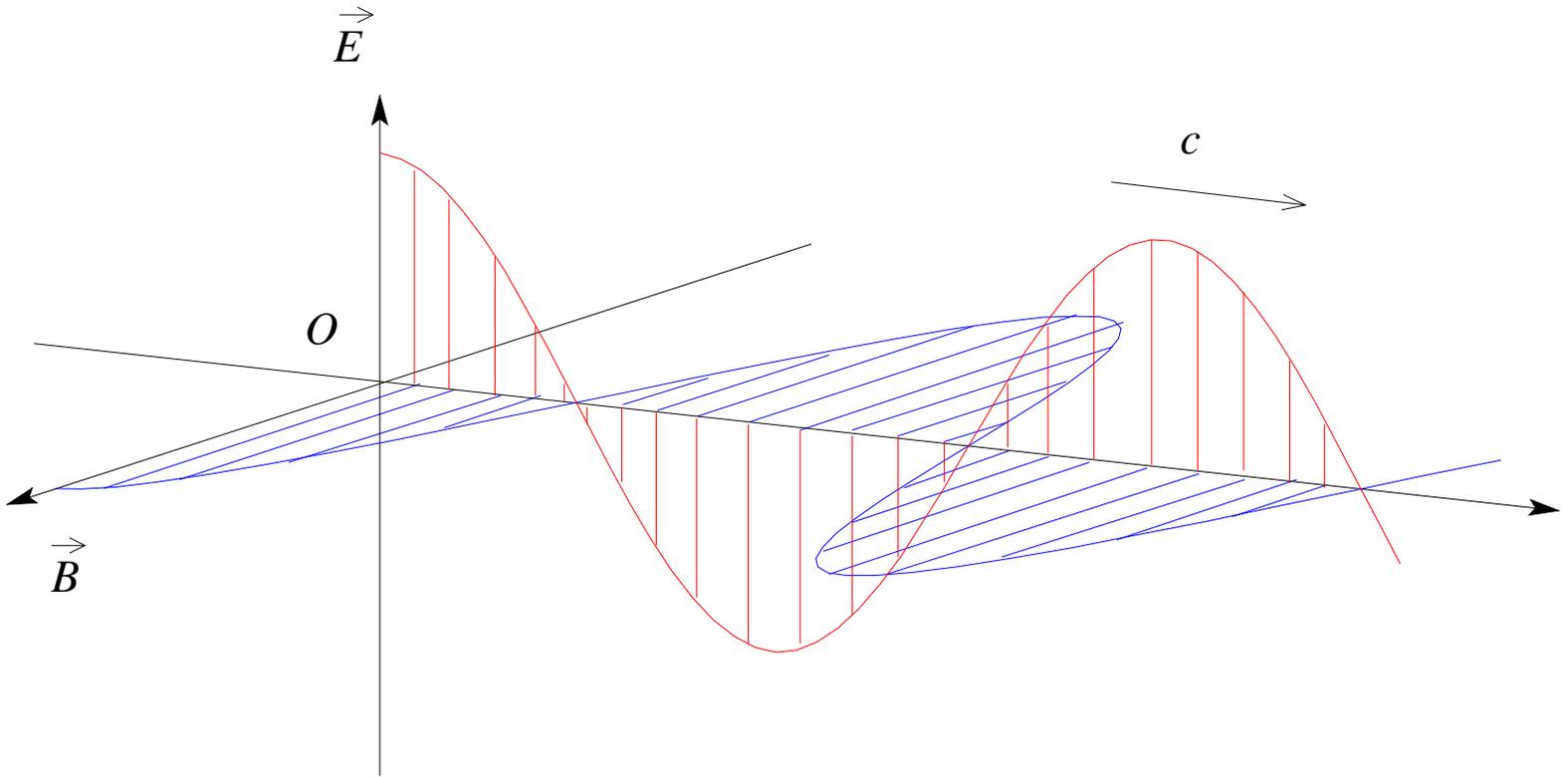
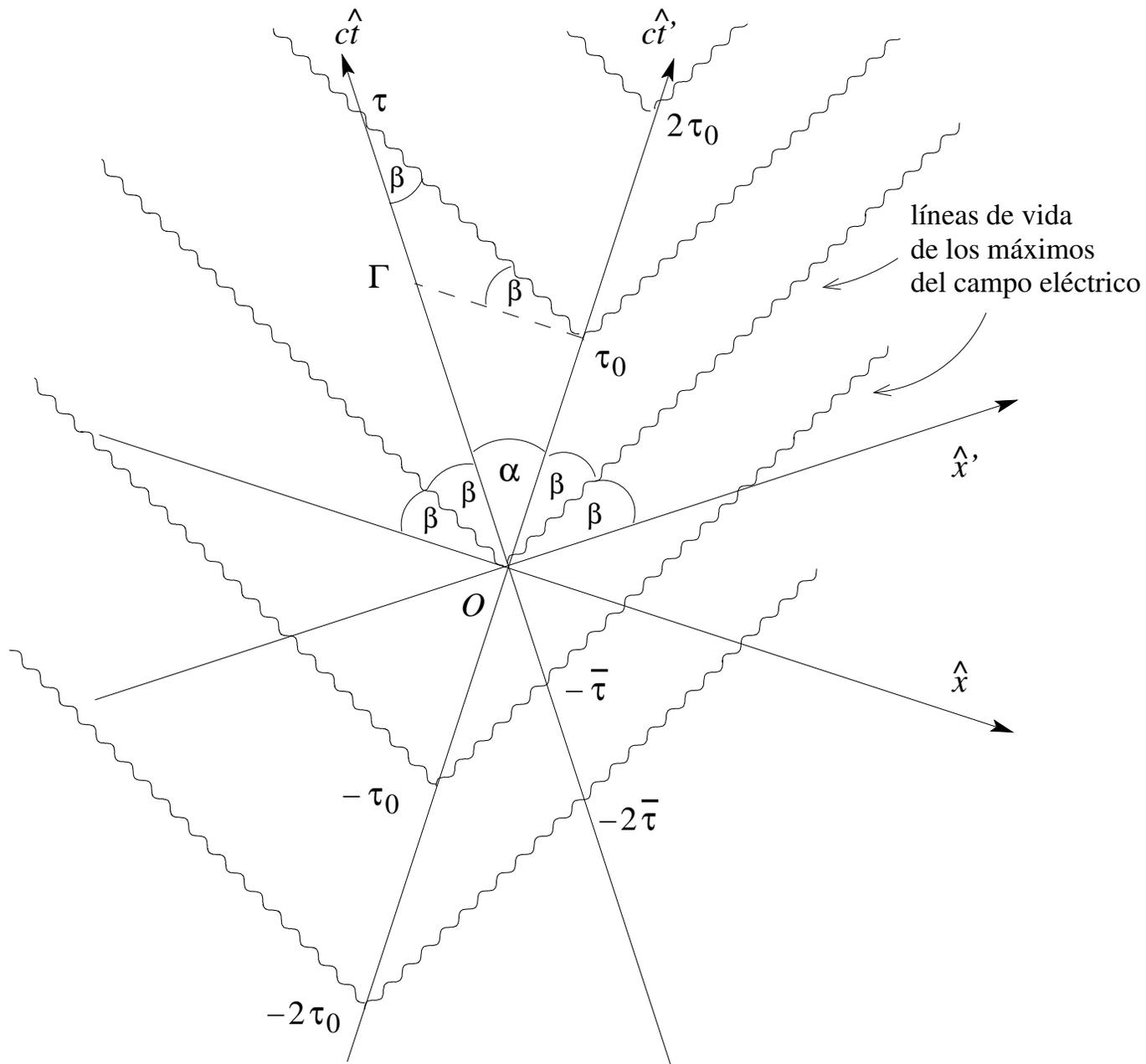


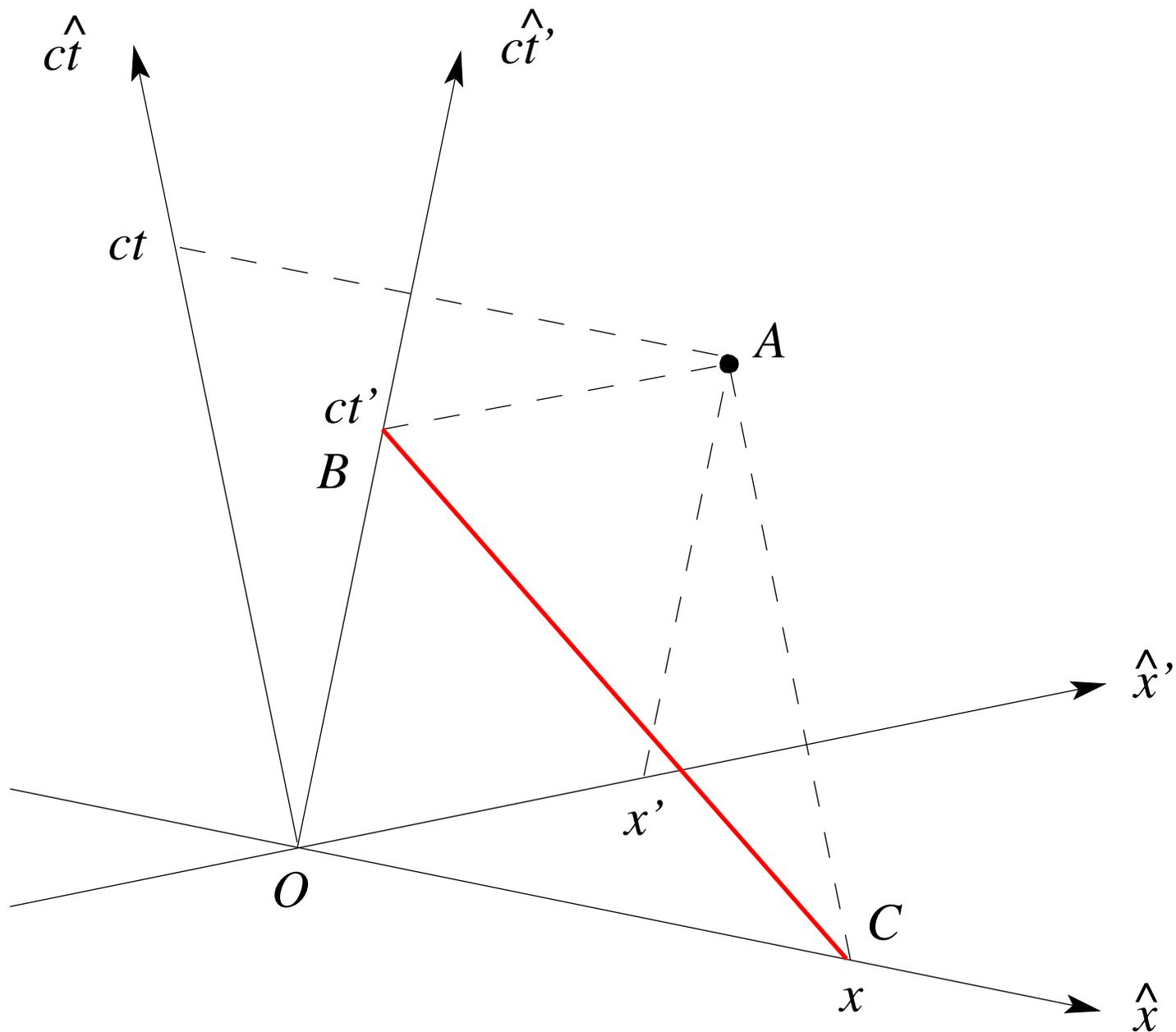
Diagrama espacio-tiempo para el viaje espacial



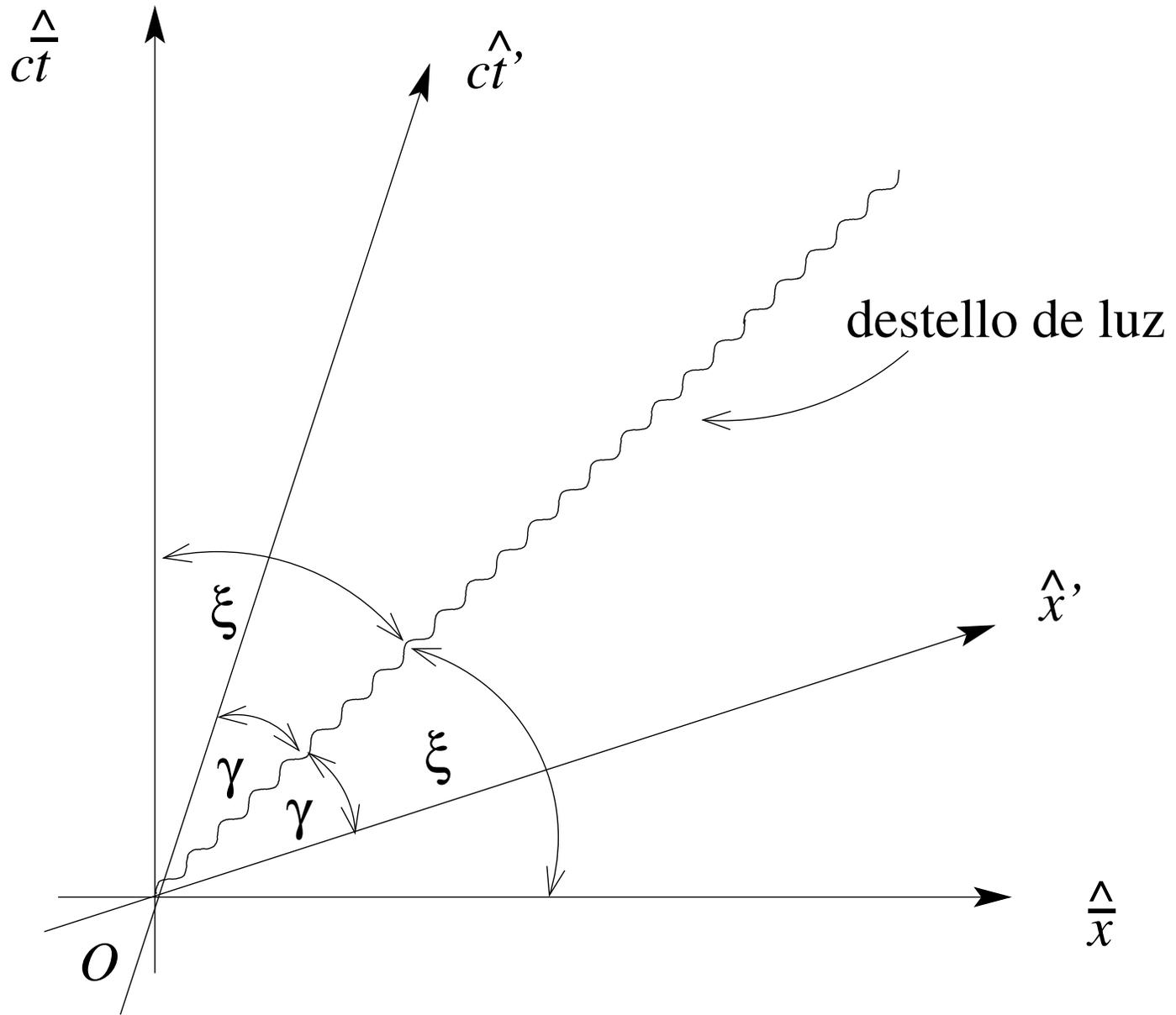
Onda electromagnética



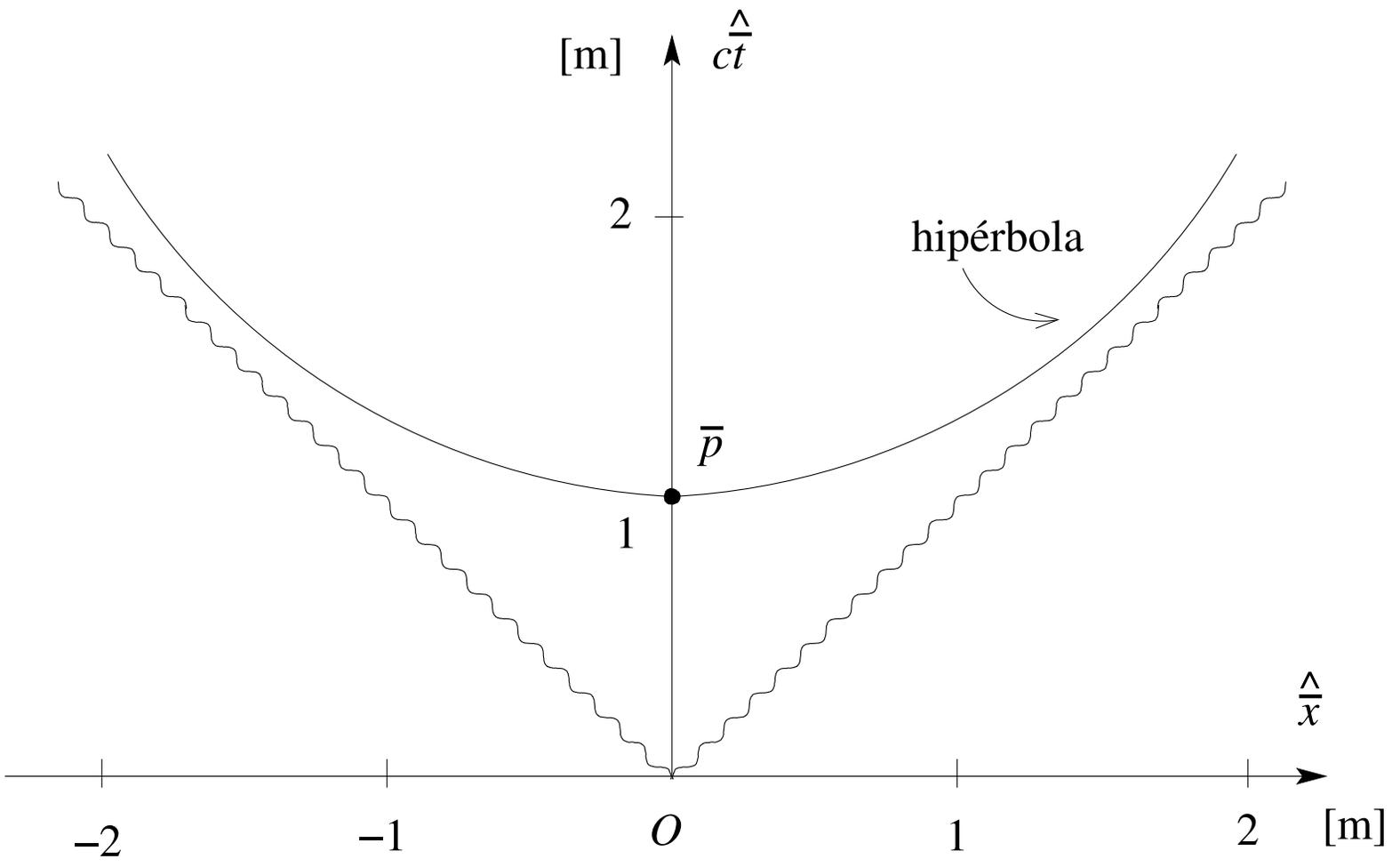
Efecto Doppler relativista



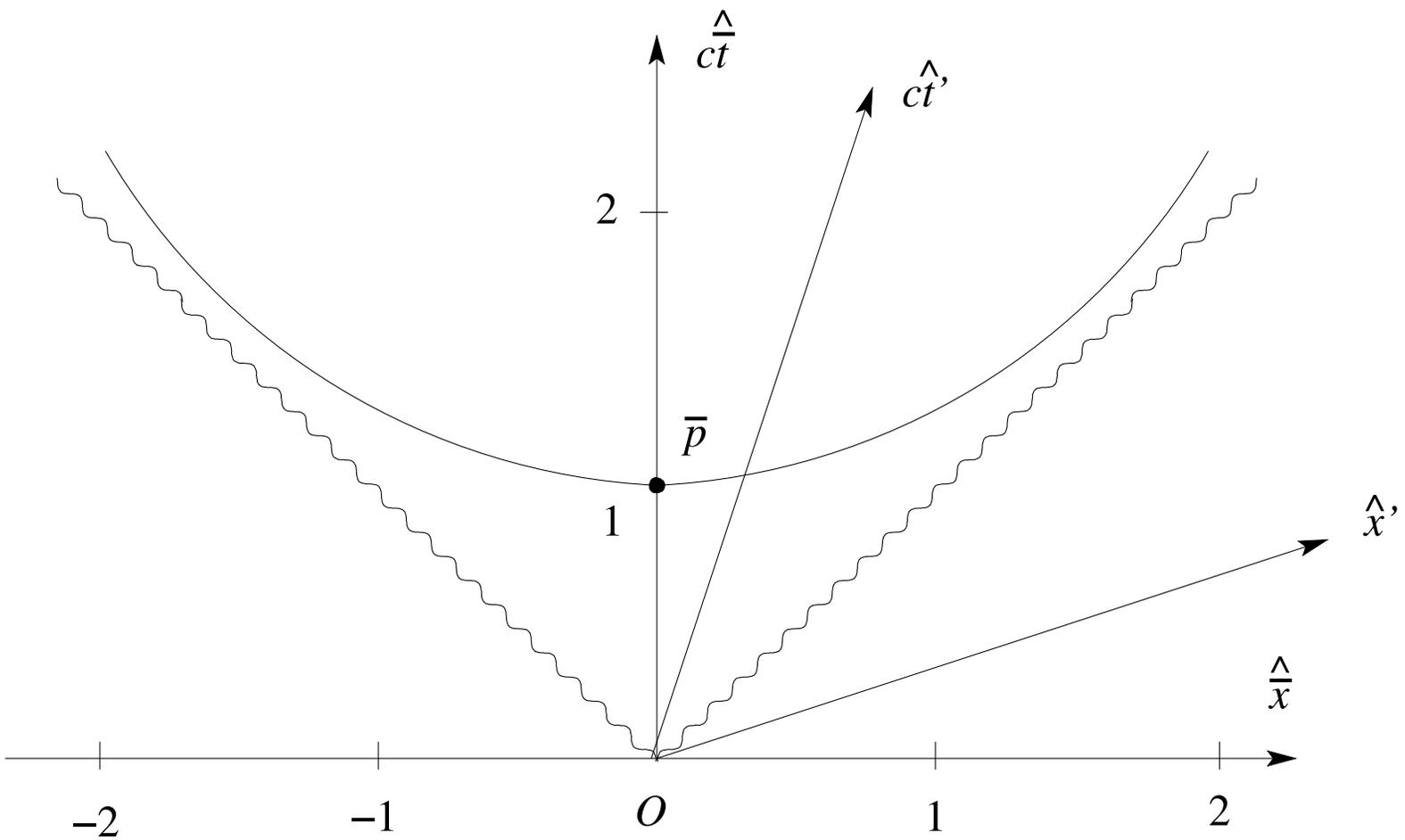
Invariancia del intervalo



Dos observadores representados de modo no equivalente



El intervalo entre el origen y la hipérbola es 1 [m]



Superposición de las dos figuras anteriores

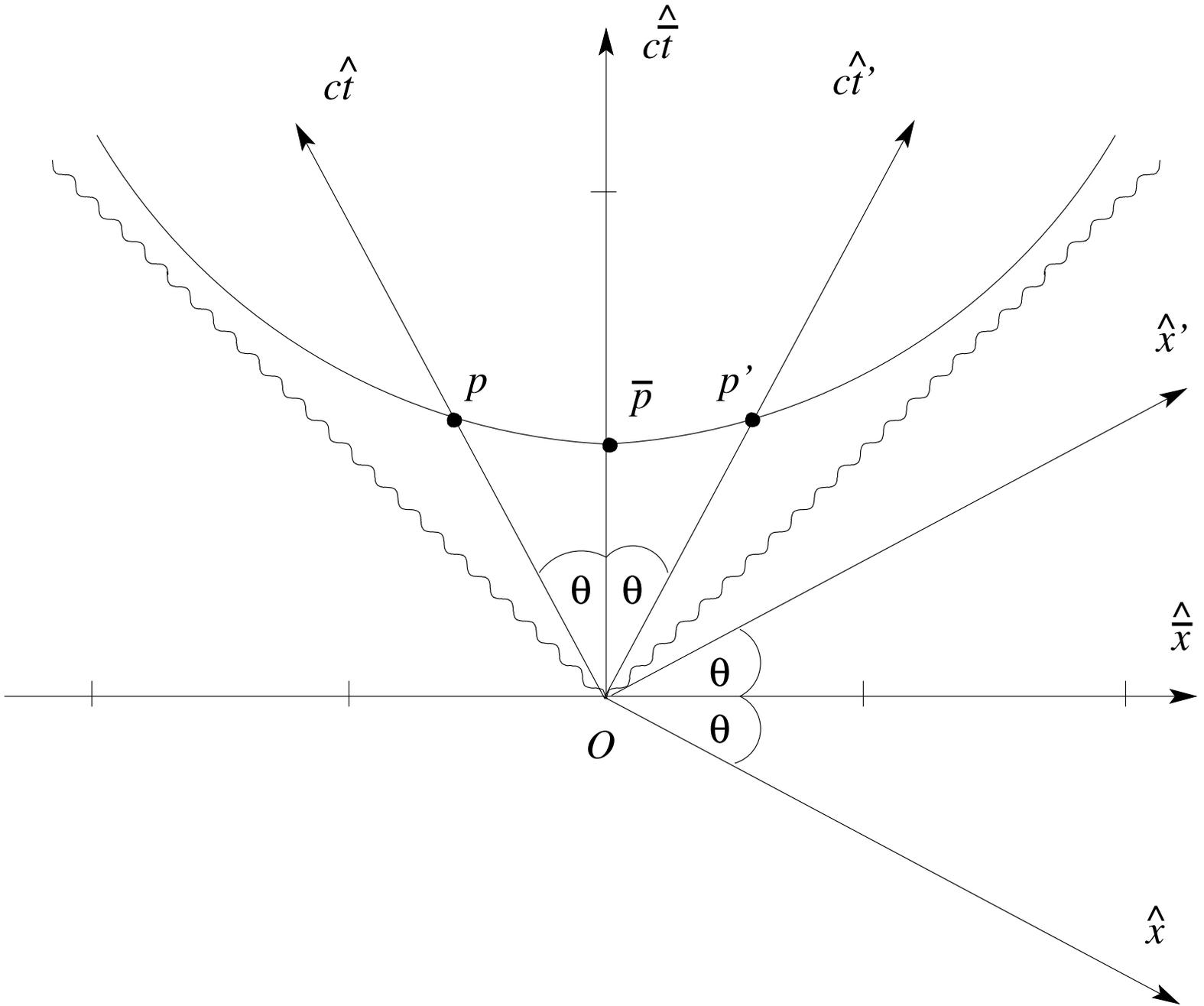


Diagrama de Minkowski para tres observadores

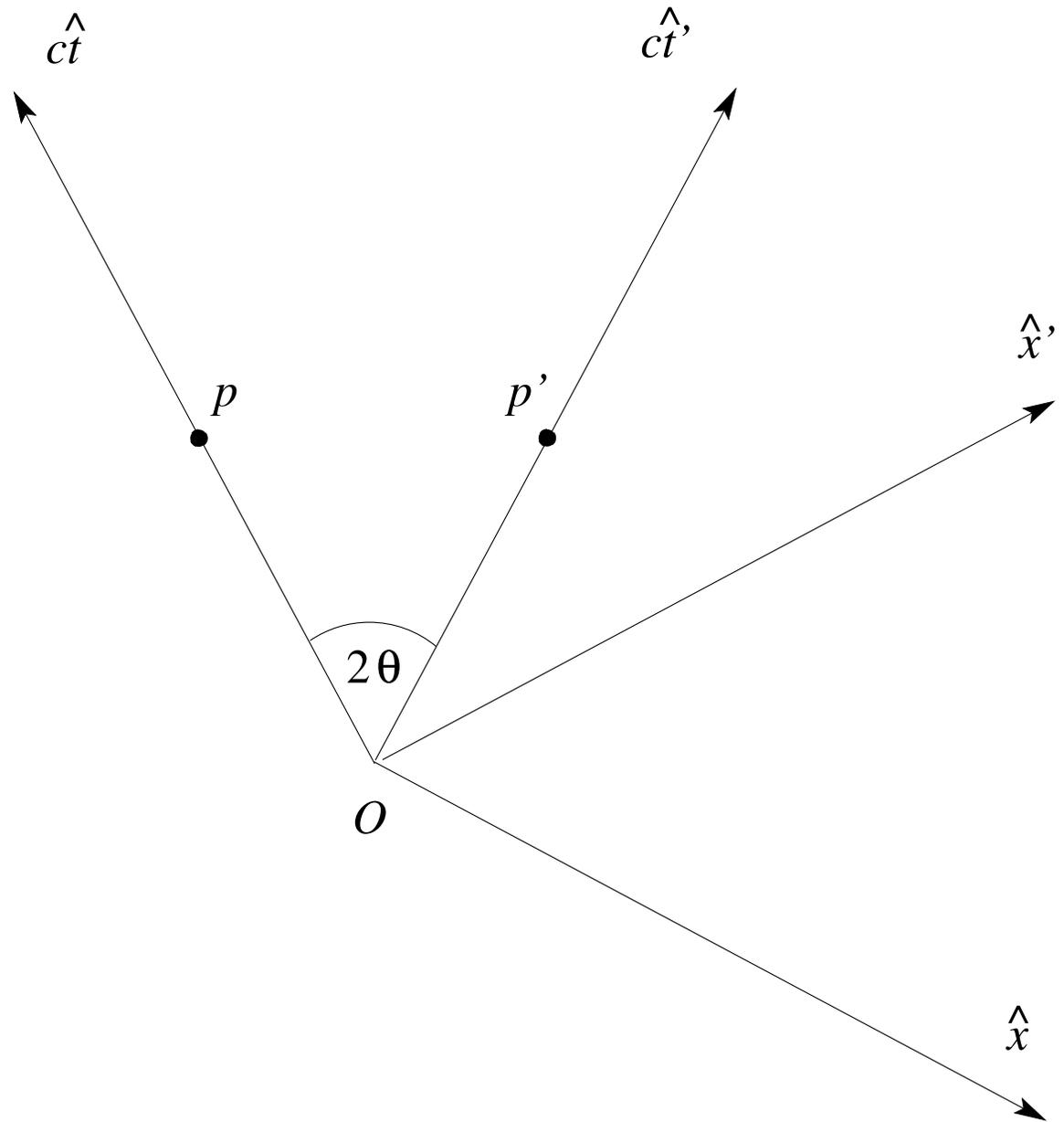


Diagrama de Minkowski anterior sin los ejes para el observador  $\bar{O}$

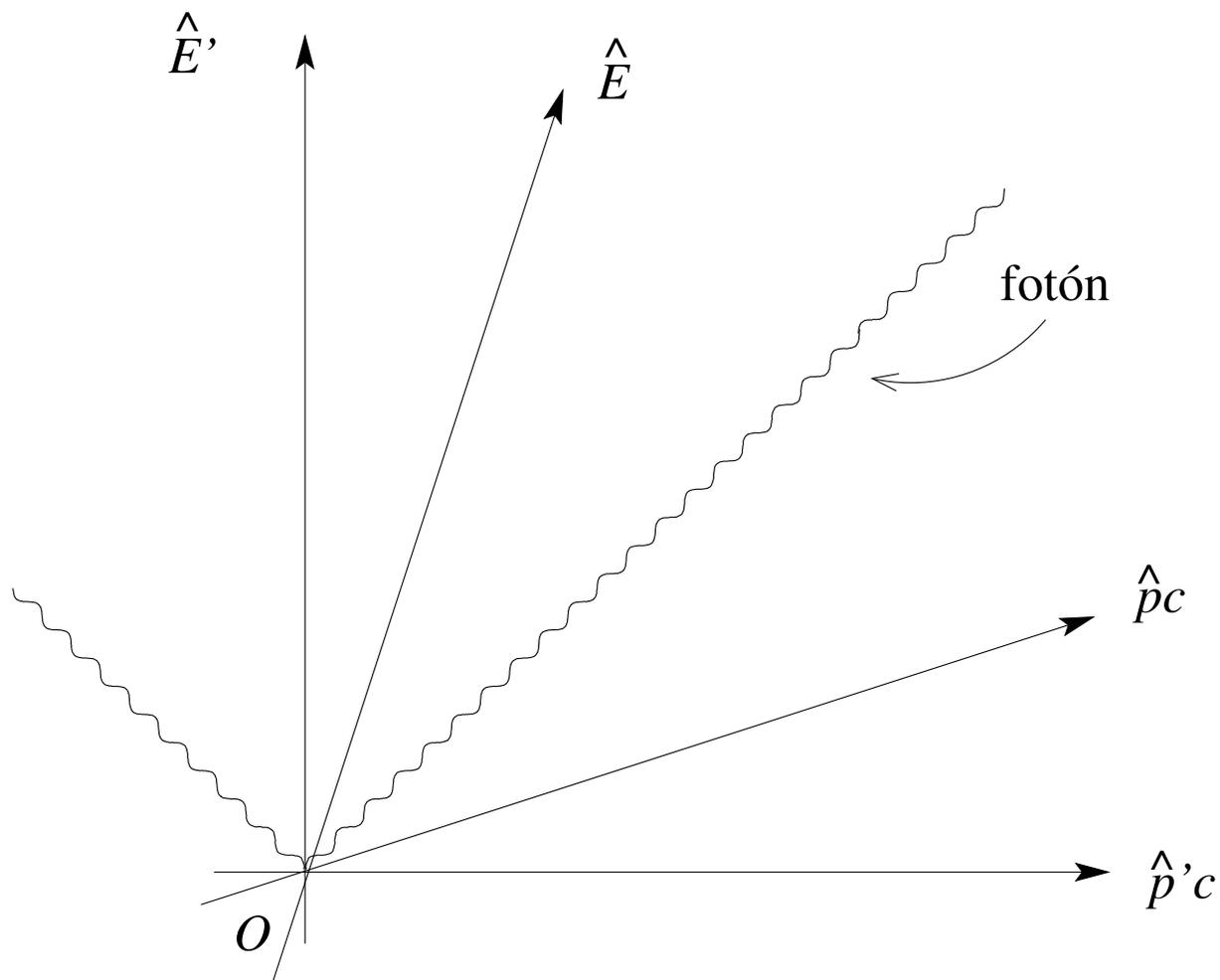
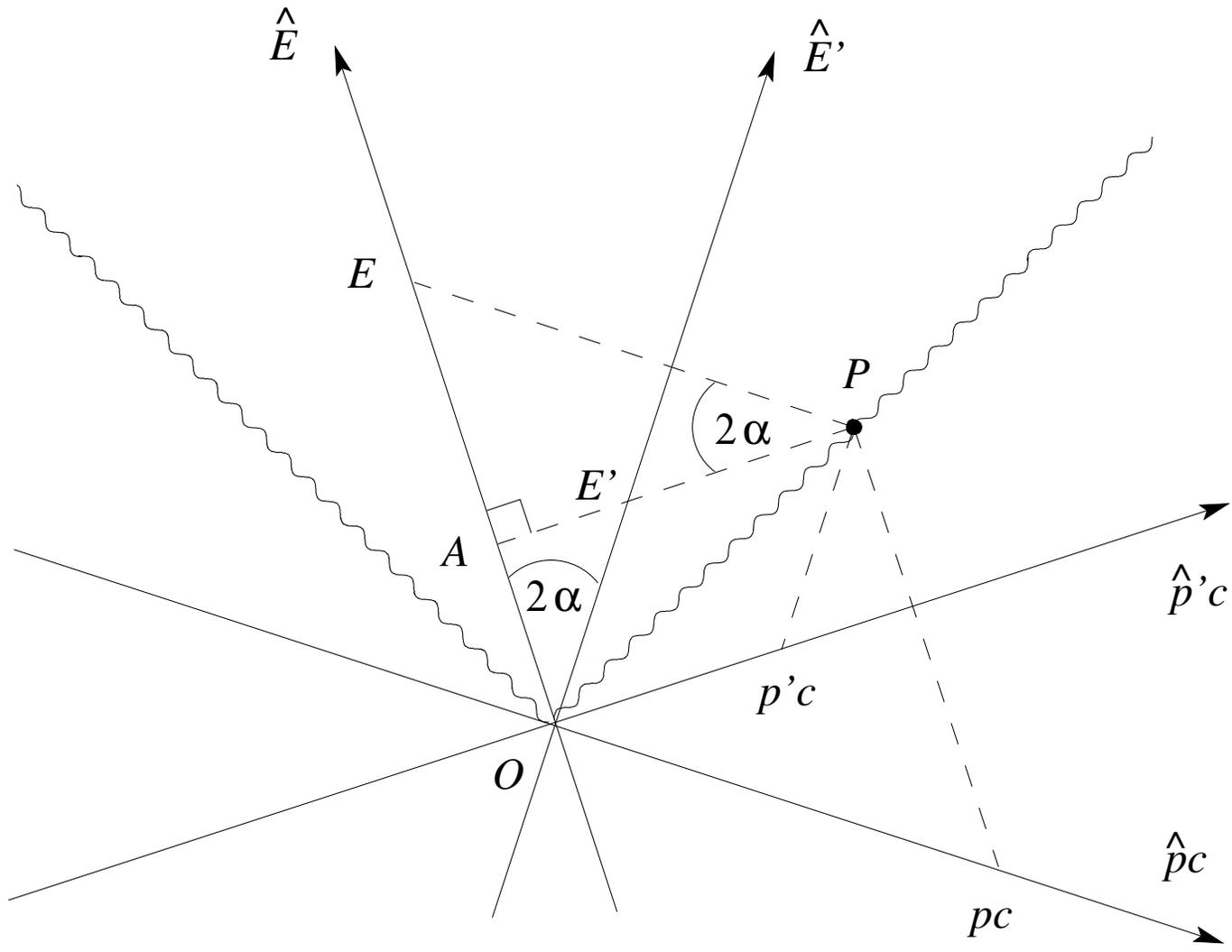
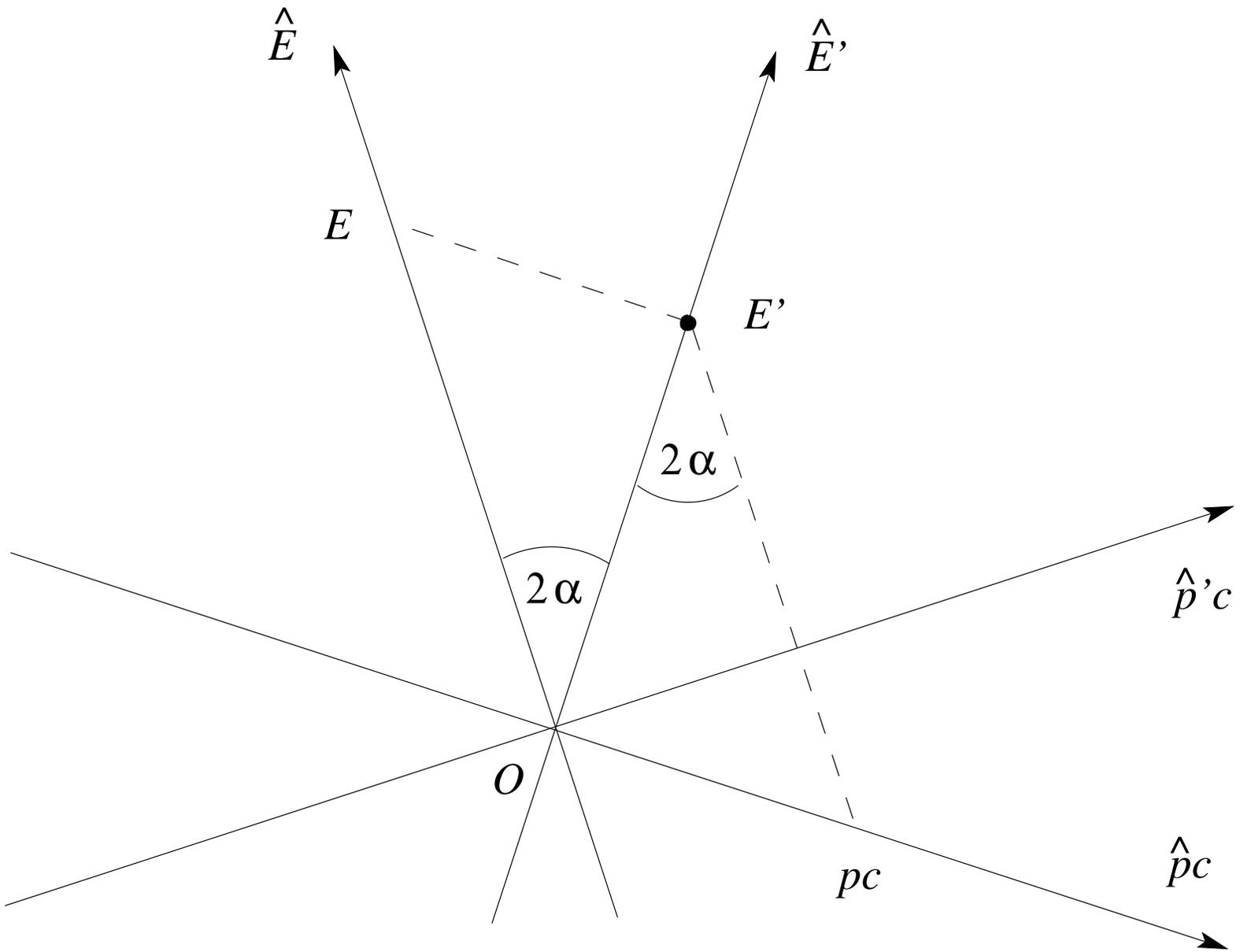


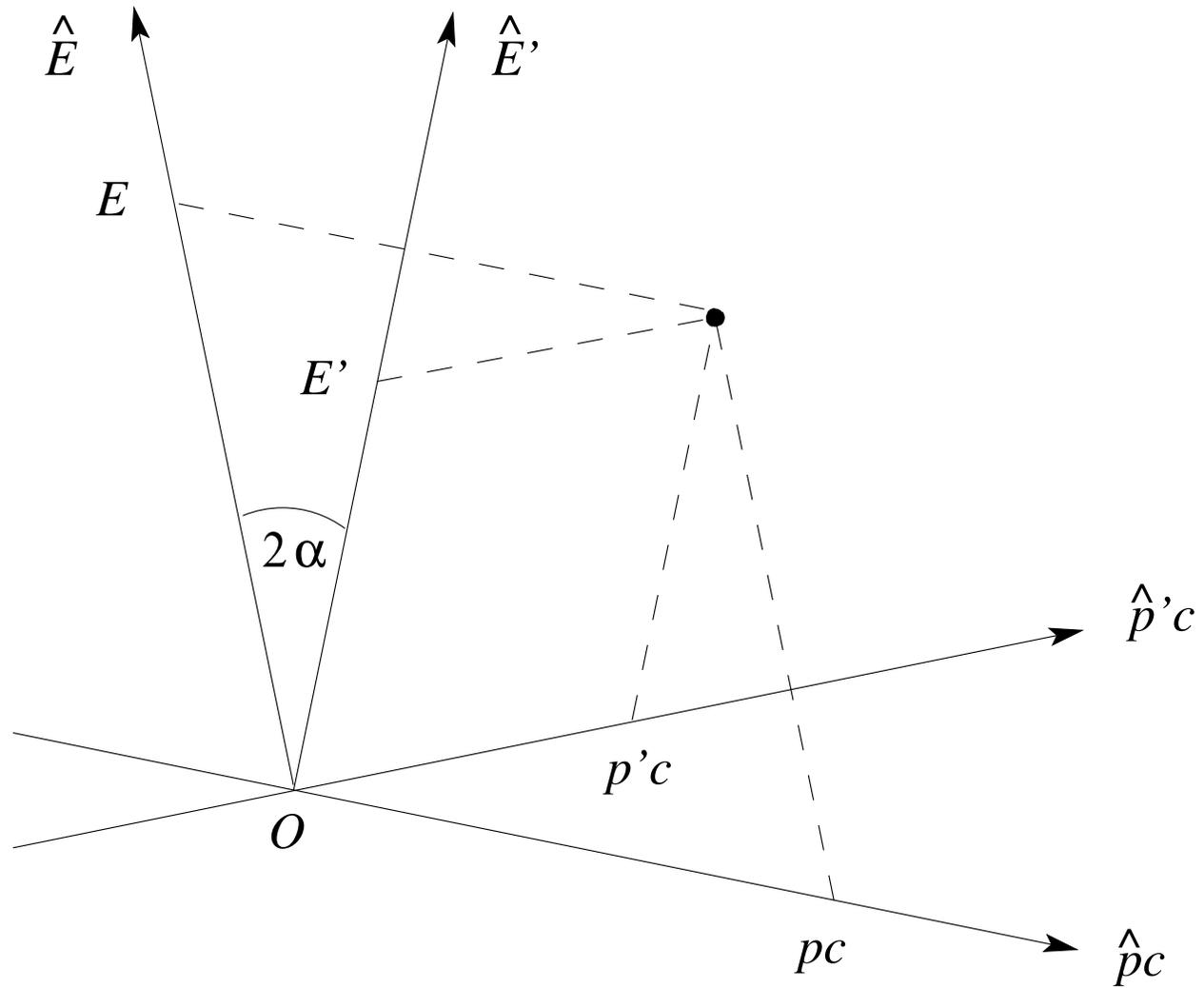
Diagrama energía–momentum para dos observadores. Primera versión.



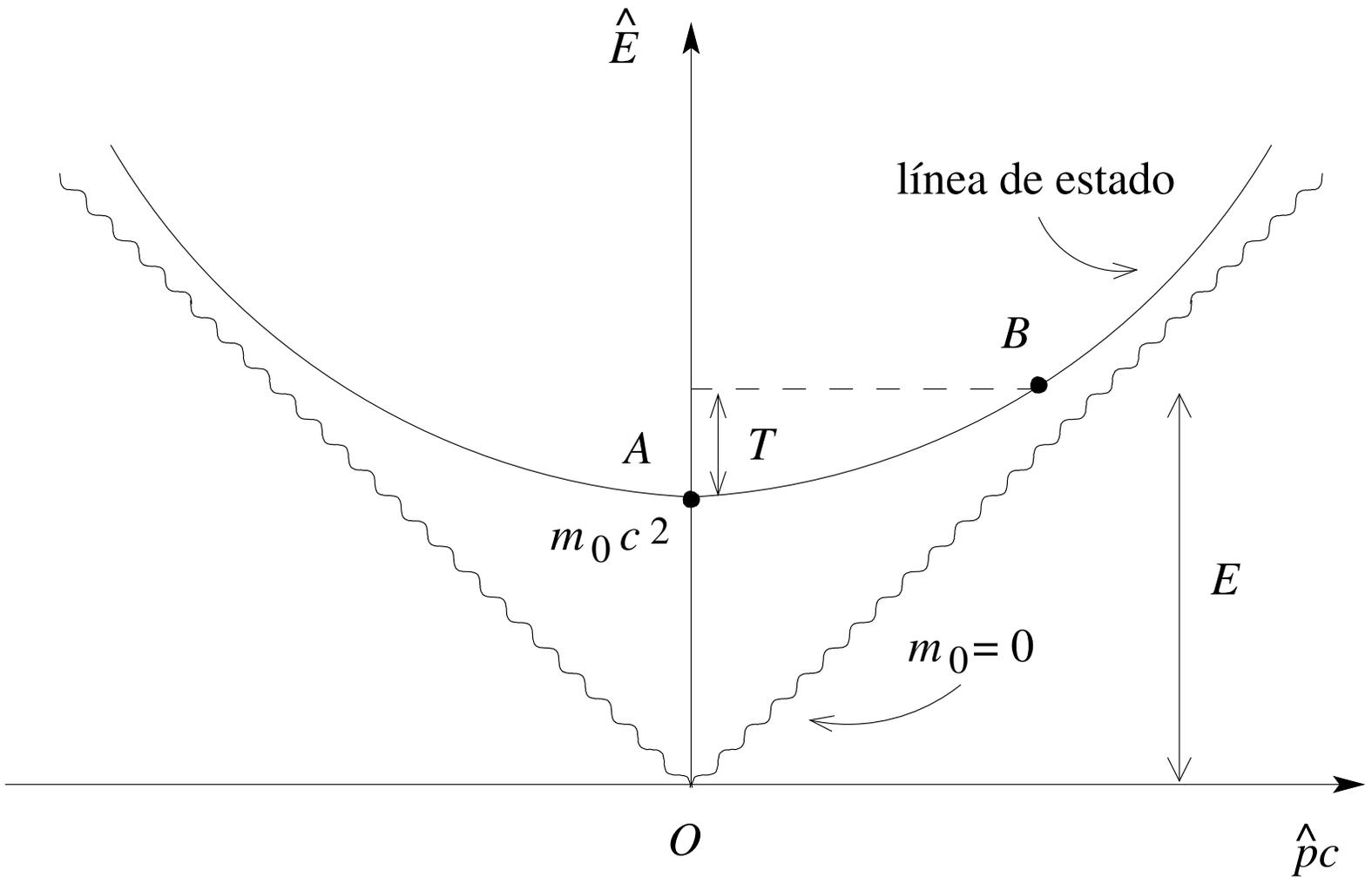
Referenciales energía–momentum para dos observadores. Segunda versión.



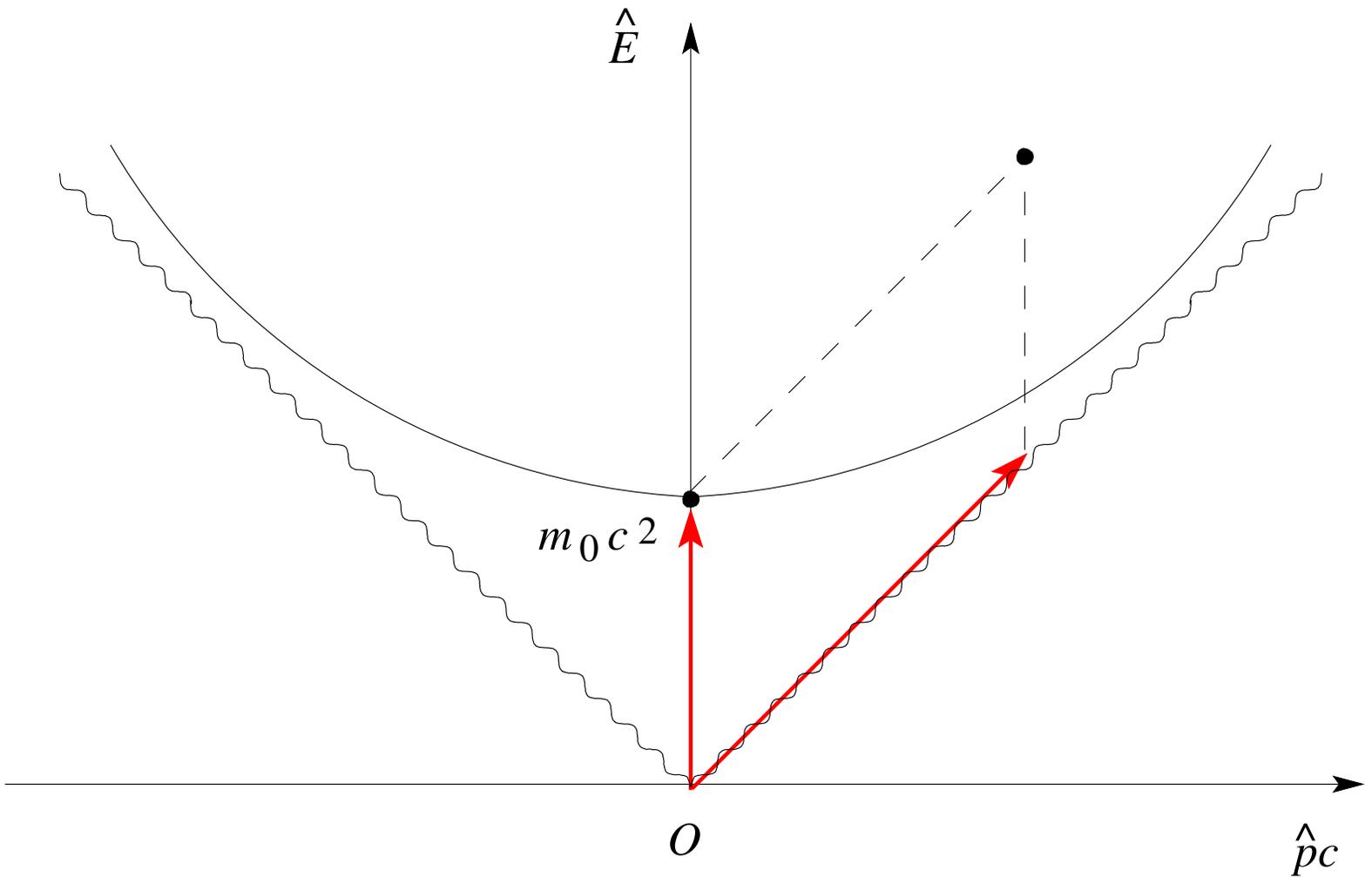
Objeto en reposo para el observador  $O'$



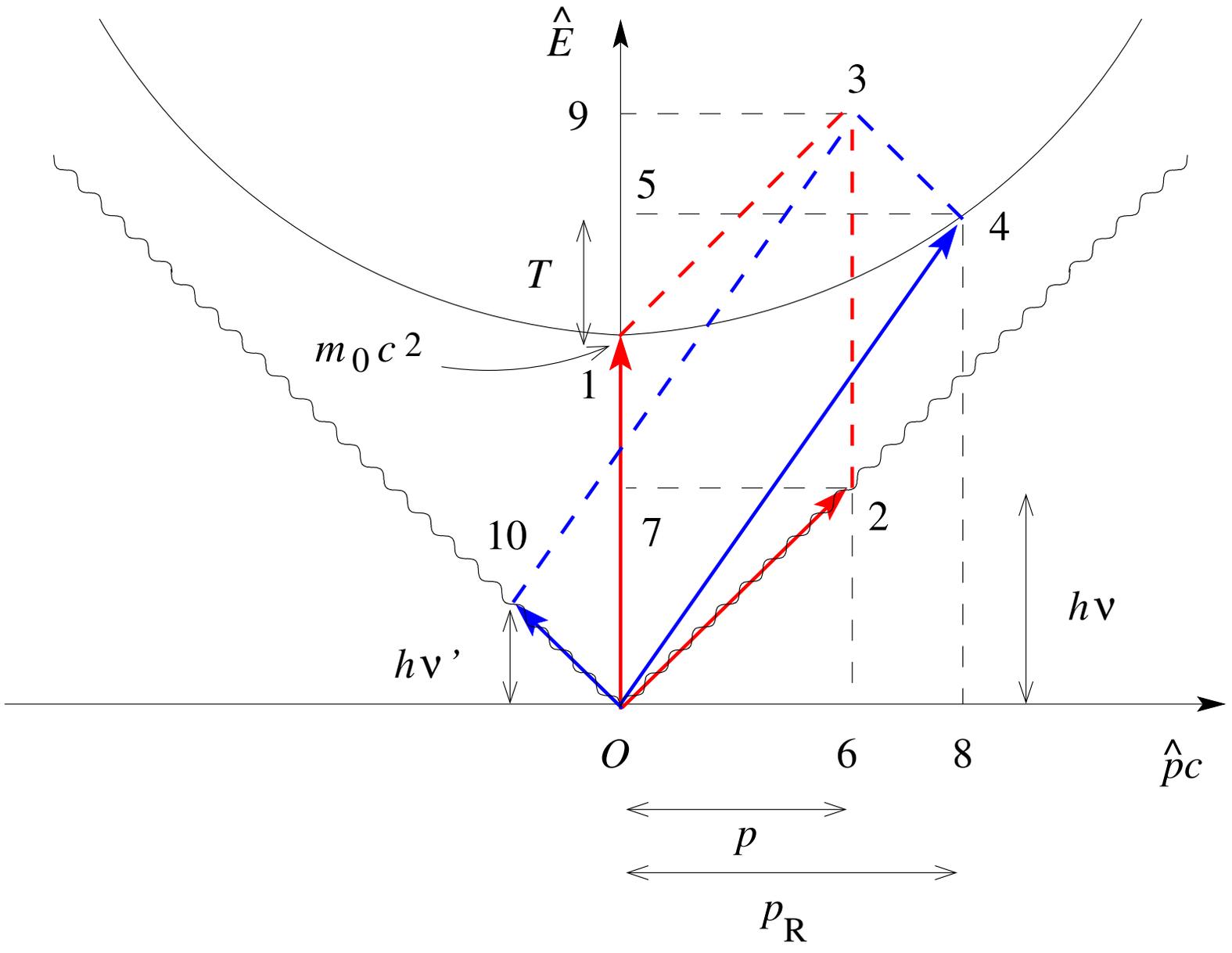
Transformaciones de coordenadas en diagramas energía-momentum



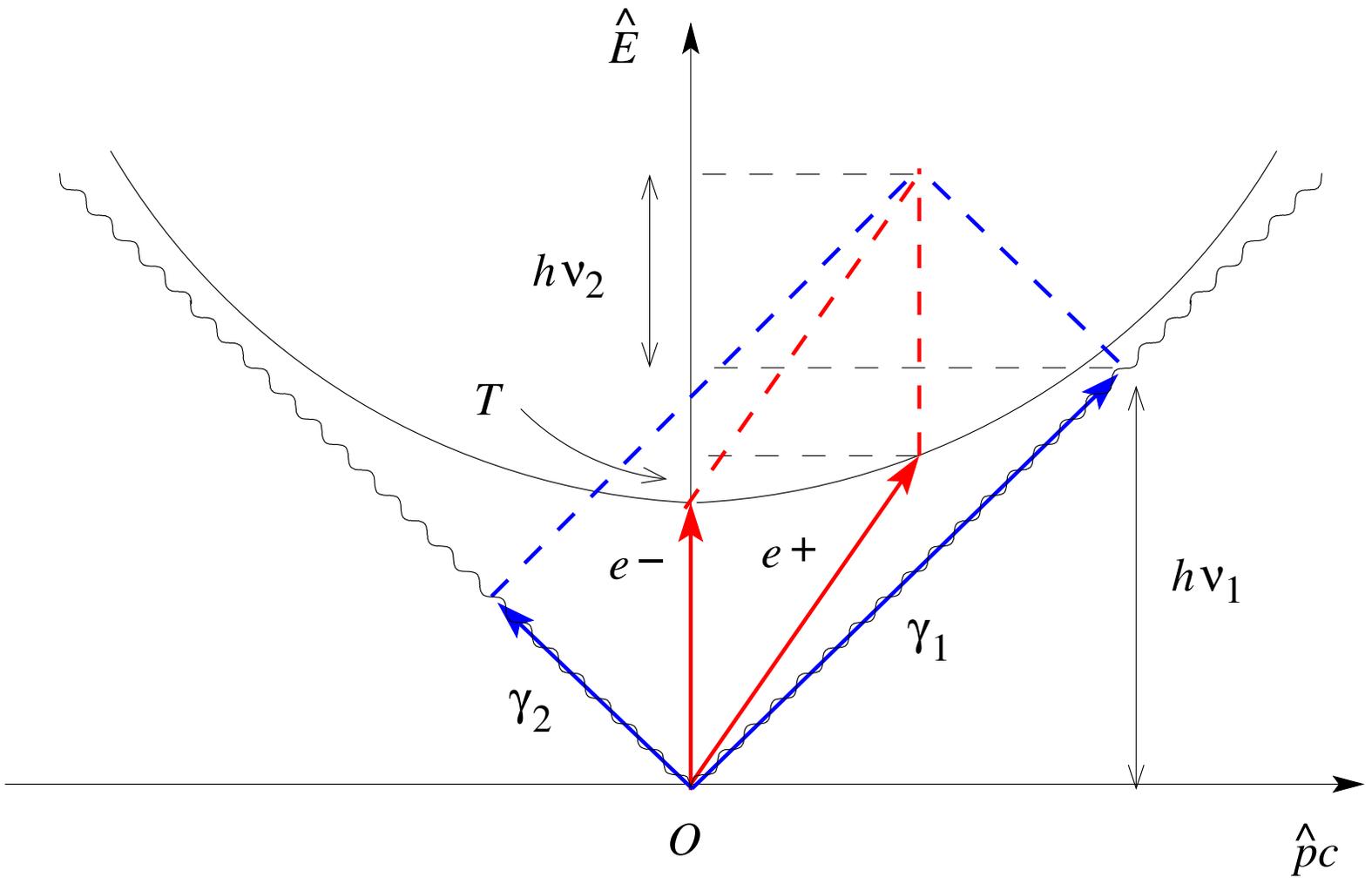
Partícula de masa  $m_0$



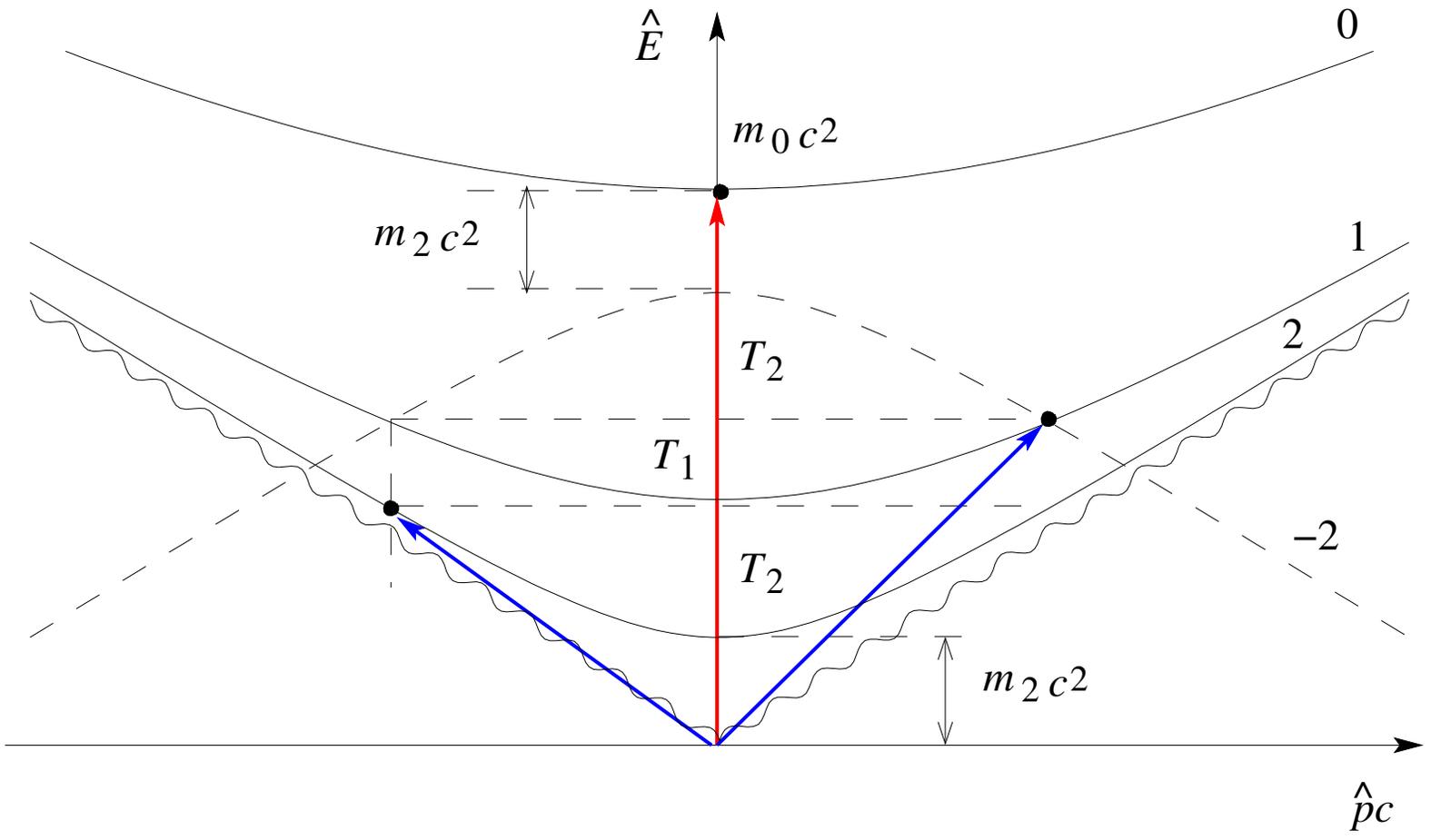
Absorción de un fotón por un electrón



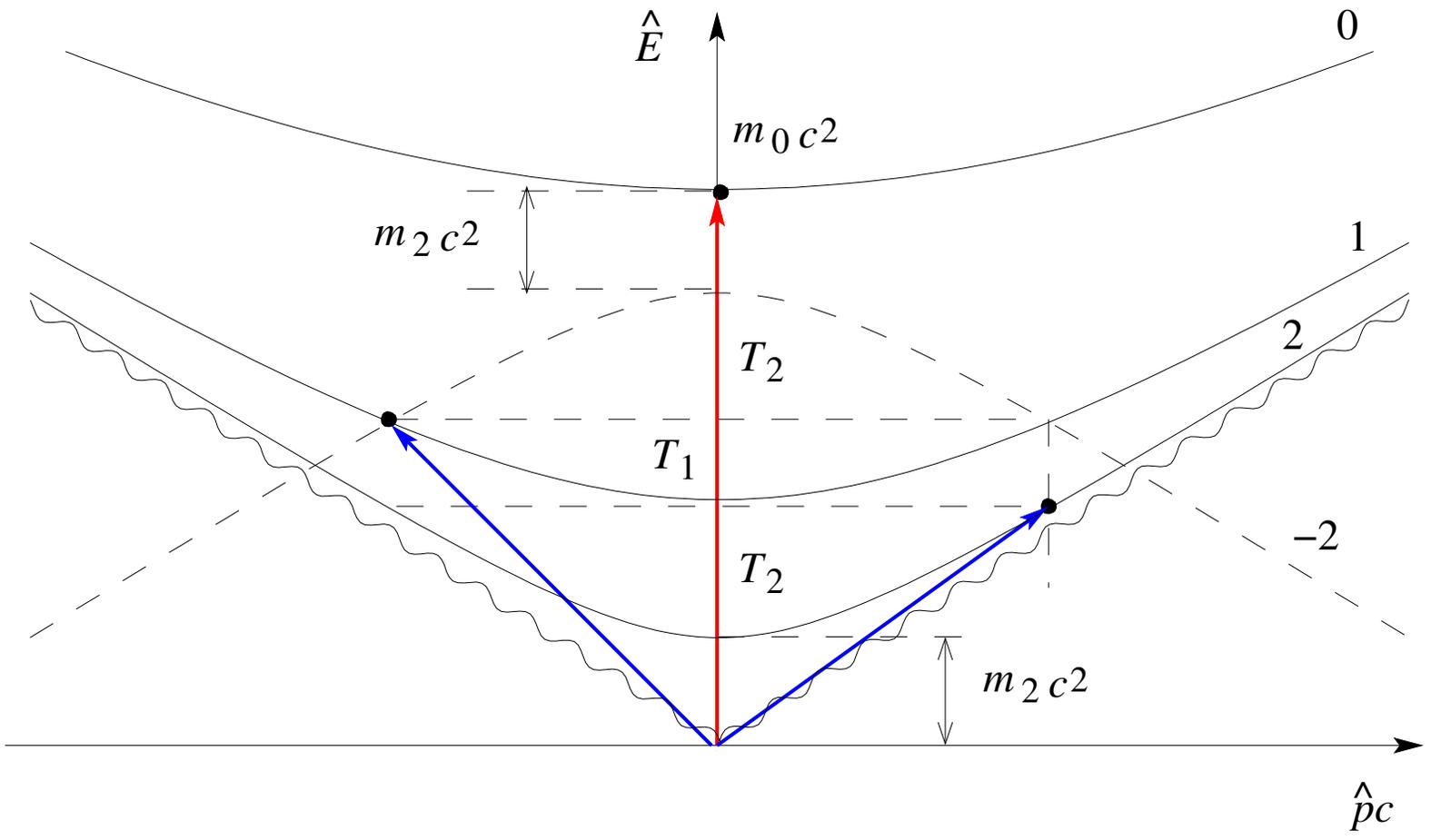
Efecto Compton



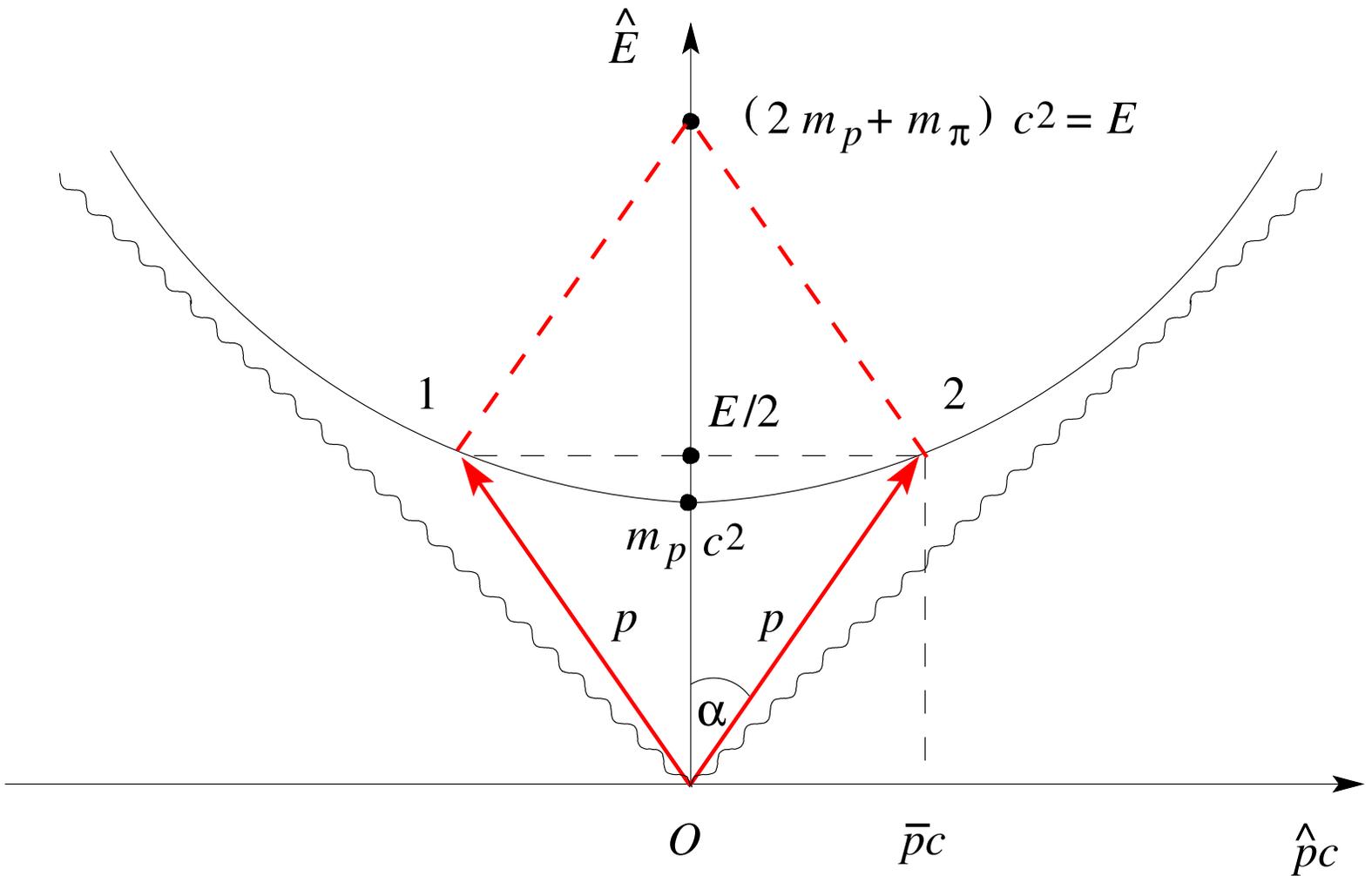
Aniquilación



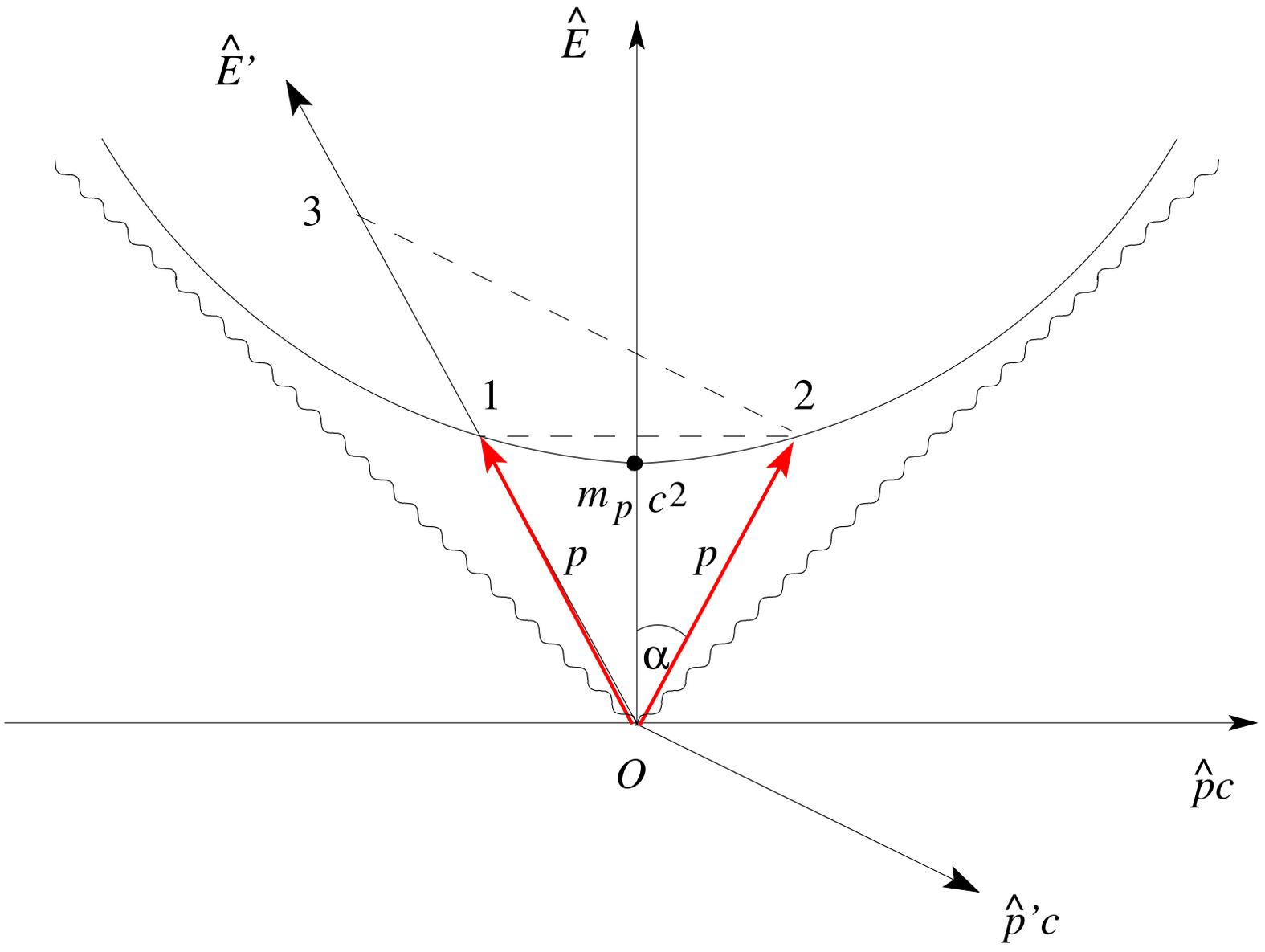
Fisión de un núcleo (primera solución)



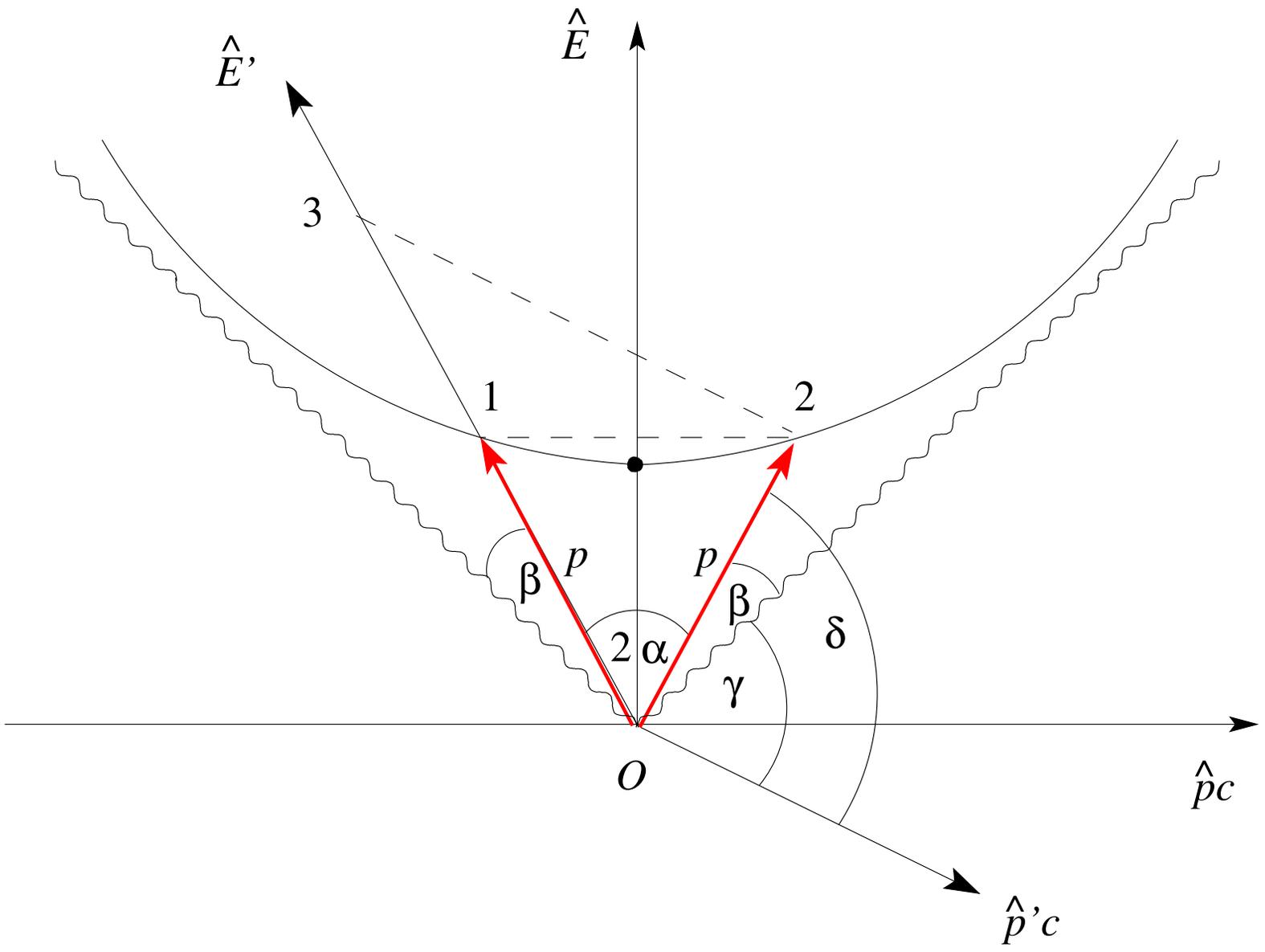
Fisión de un núcleo (segunda solución)



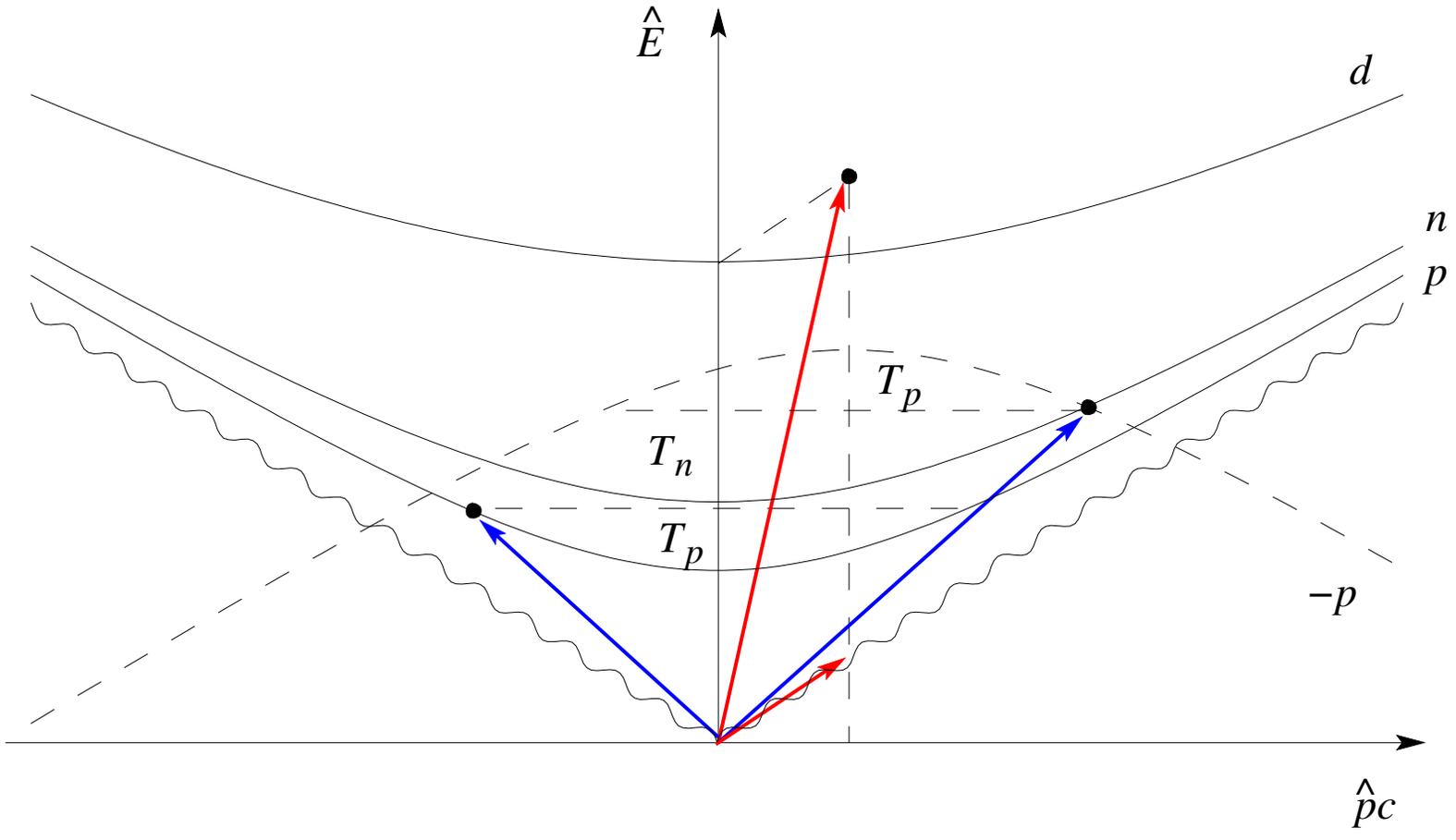
Energía umbral. Solución en el centro de masas.



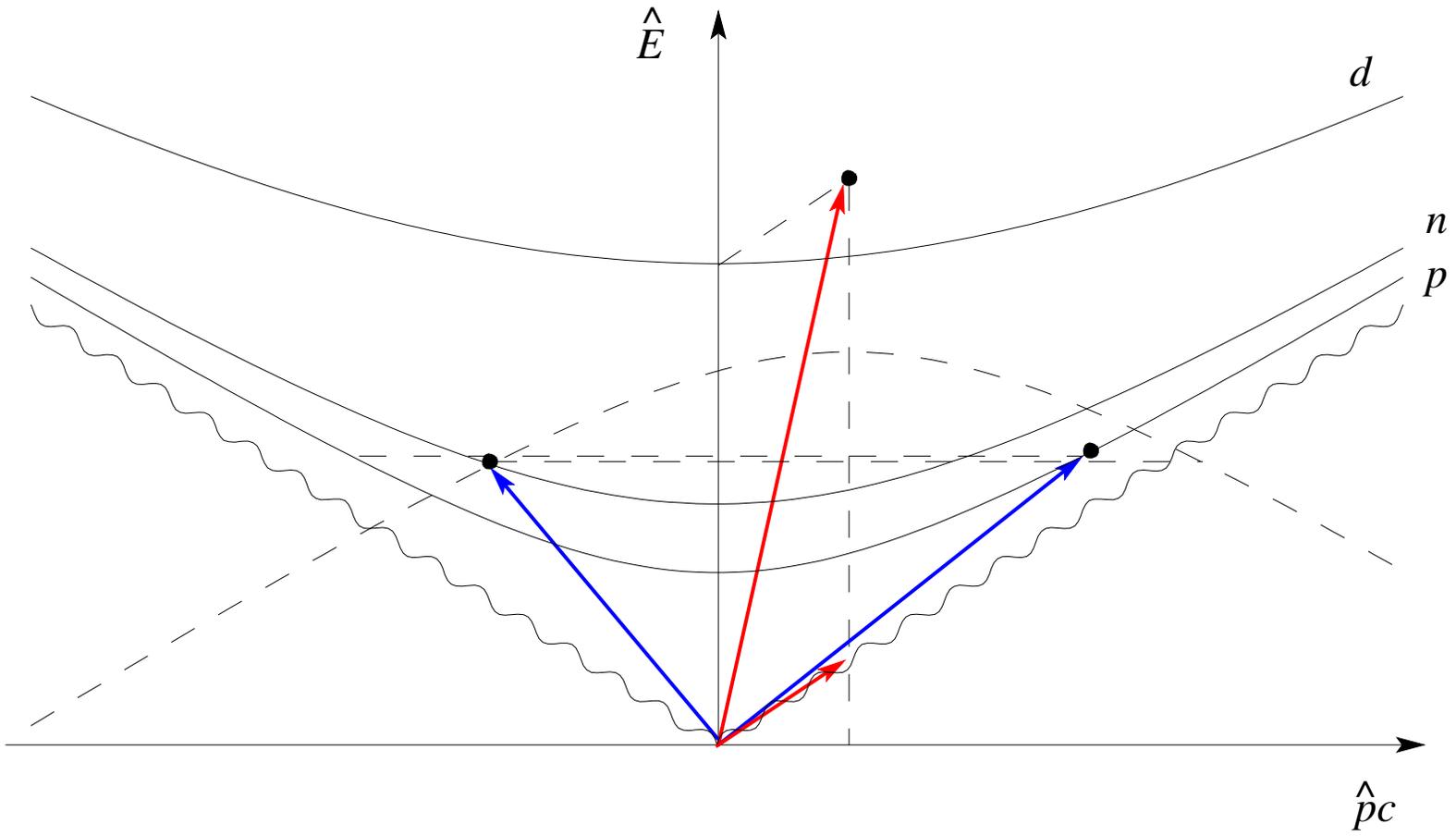
Energía umbral. Solución en el laboratorio.



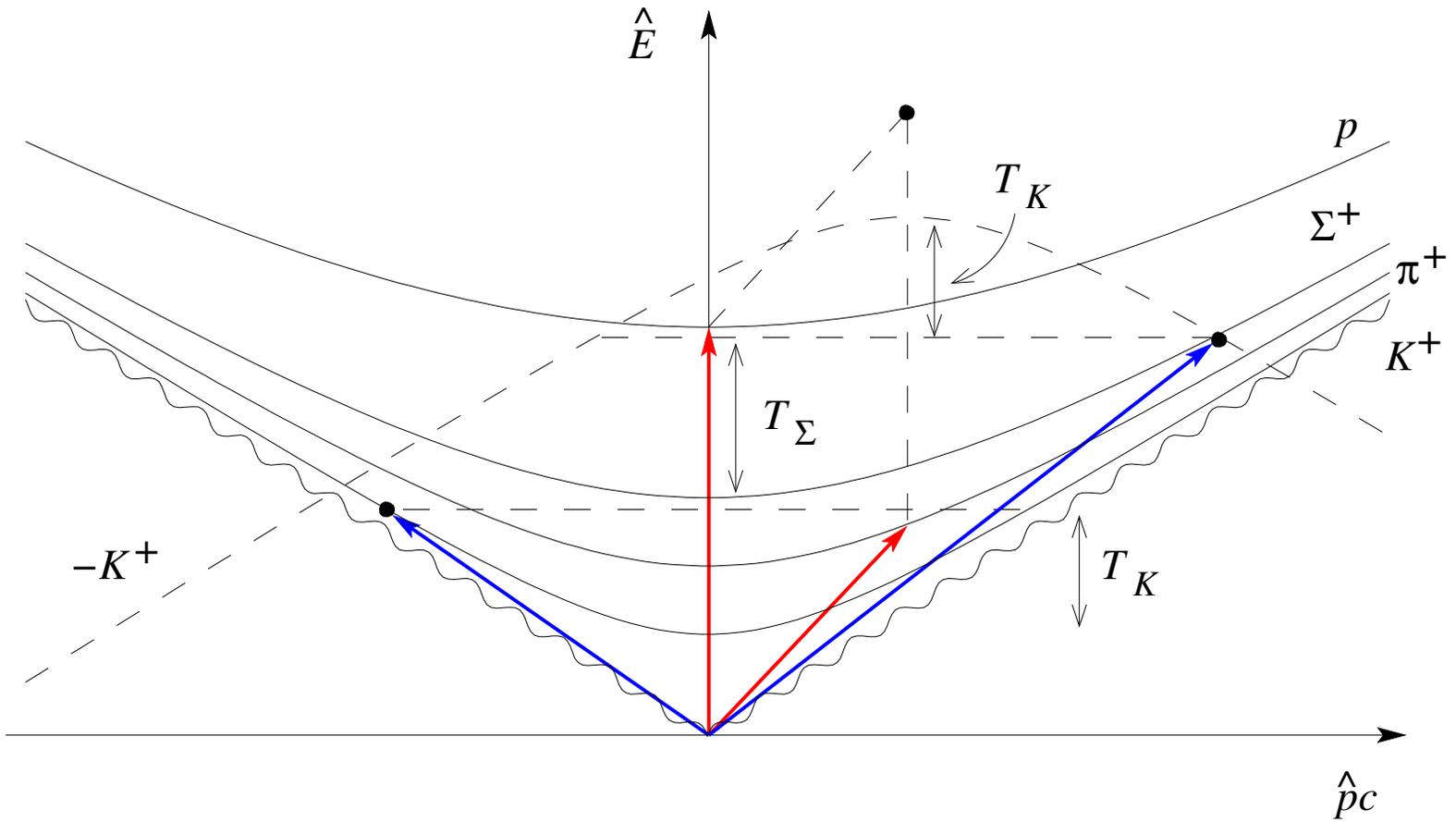
Energía umbral. Solución en el laboratorio. Ángulo 2 es recto.



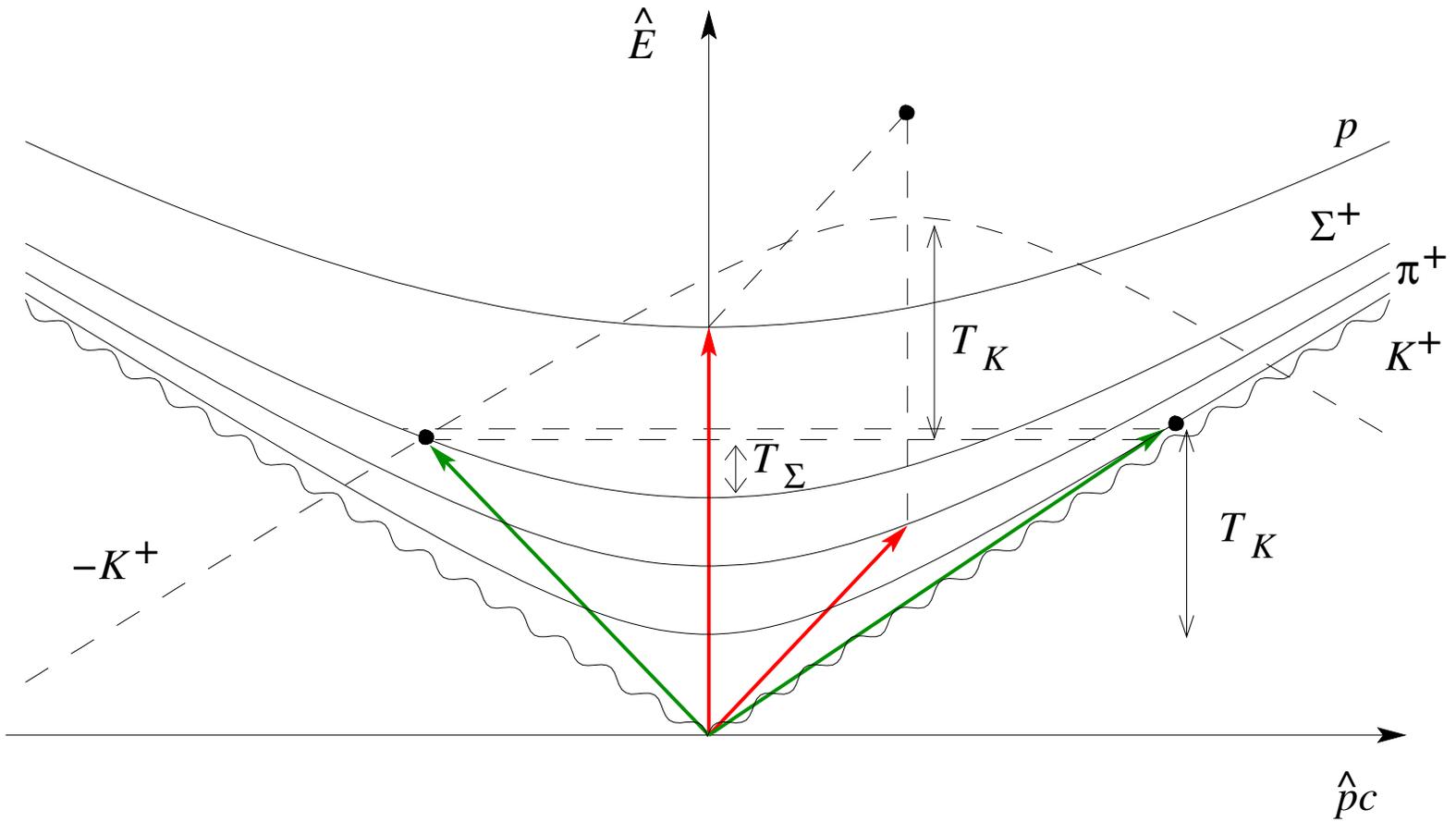
Fotodestrucción



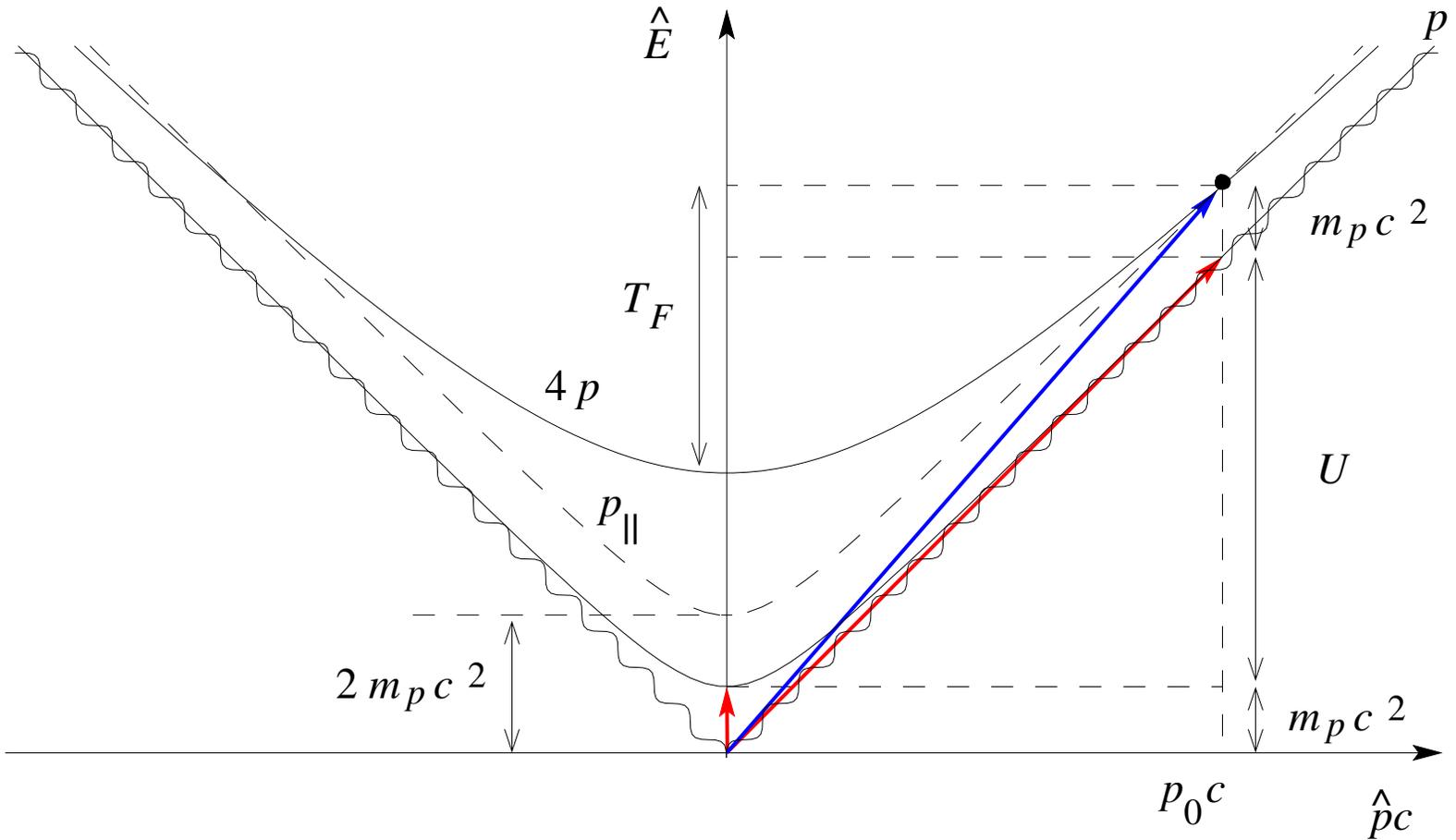
Fotodestrucción (segunda solución)



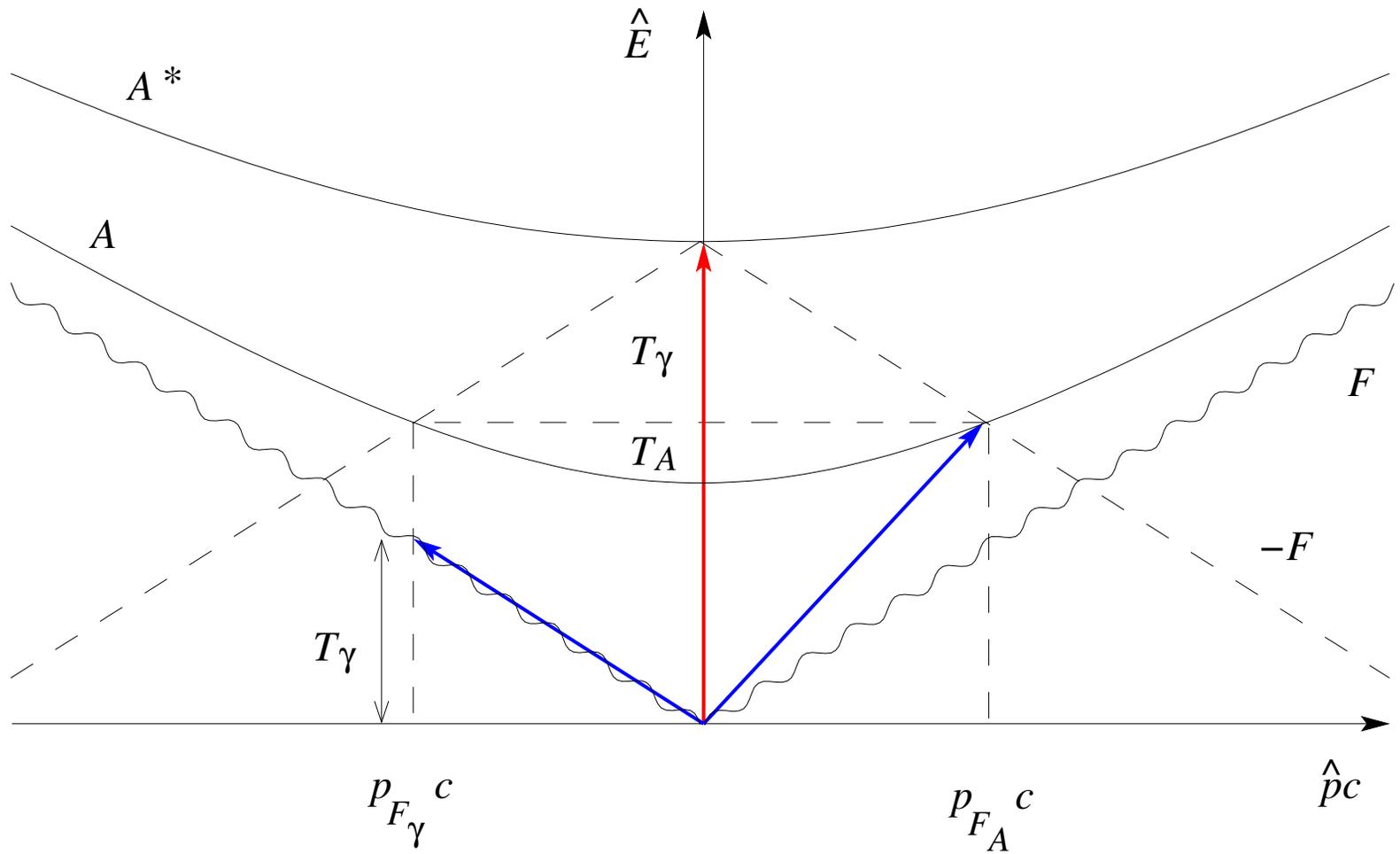
Colisión pión-protón



Colisión pión-protón. Segunda solución.



Colisión protón-protón



Decaimiento de un átomo excitado