CONCORSO PER TITOLI ED ESAMI PER UN POSTO PER IL PROFILO DI TECNOLOGO DI III LIVELLO PROFESSIONALE, PER ASSUNZIONE A TEMPO INDETERMINATO PRESSO I LABORATORI NAZIONALI DEL SUD DELL'INFN

BANDO N. 22209/2020

Allegato 1

QUESITI PROVA ORALE

1. Che relazione sussiste tra l'energia massima ottenibile da un ciclotrone ed il rapporto q/A della specie ionica da accelerare? Descrivere qualitativamente il fenomeno che può impedire l'ottenimento di tali energie ed indicare che relazione ha con il rapporto q/A della specie ionica da accelerare.

2. Il candidato discuta le problematiche causate dalla carica spaziale nelle linee di trasporto a bassa energia di fasci ionici intensi ed eventuali metodologie per mitigarne gli effetti.

3. Il candidato discuta il principio di funzionamento di un acceleratore elettrostatico (ad es. Tandem) evidenziandone le problematiche tecniche più significative.

4. Il candidato discuta il principio di funzionamento di un ciclotrone evidenziandone le problematiche tecniche più significative.

5. Il candidato illustri una linea di trasporto per la selezione delle specie generate da una sorgente ionica di ioni multicarichi e le relative criticità.

6. Il candidato illustri una linea di trasporto per fasci ionici leggeri ad alta intensità e bassa energia e le relative criticità.

1 ALLEGATO 3 PROVA INGLESE

positions, w_κ is the Fourier transform of the electron-ion term $W(\mathbf{x})$ and ρ^e_κ is the electron density fluctuation in reciprocal space. The result obtained for H_{ei} shows that only the longitudinal mode $Q_{\kappa l=1}$ contributes, which derives from the gradient of $W(\mathbf{x})$ being parallel to κ. It is usual to approximate w_κ including a form factor $F(\kappa)$ accounting for the finite size of the ion core, that is $w_\kappa = 4\pi e^2 Z_i F(\kappa)/\kappa^2$.

Casting together the purely ionic term with the electron-ion coupling term, the Hamiltonian describing the fast vibrational dynamics in liquids is obtained as

$$\mathcal{H}_{ph} = \frac{1}{2}\sum_{\kappa l}\left\{\left[P^\dagger_{\kappa l}P_{\kappa l} + \Omega^2_{\kappa l}\,Q^\dagger_{\kappa l}Q_{\kappa l}\right] - i\,\frac{1}{V}\sqrt{\frac{N_i}{M}}\,\kappa\, w_\kappa\, \rho^e_{-\kappa}\, Q_{\kappa l=1}\right\}$$

with $\mathcal{H}_{ph}$ so called because of the similarity with phonons in crystals. The electron density ρ^e_κ can be related to the ion density ρ_κ fluctuations at the frequency ω by the dielectric function through the following equation

$$\rho_\kappa = \frac{1-\epsilon(\kappa,\omega)}{\epsilon(\kappa,\omega)}\,\rho^e_\kappa$$

where the ion density fluctuation ρ_κ is given, after some manipulation, by

$$\rho_{-\kappa} \simeq -i\sum_j \exp[-i\kappa\cdot\mathbf{R}^{(0)}_j]\,\kappa\cdot\mathbf{u}_j = i\sqrt{\frac{N_i}{M}}\kappa\, Q^\dagger_{\kappa l=1} \tag{9}$$

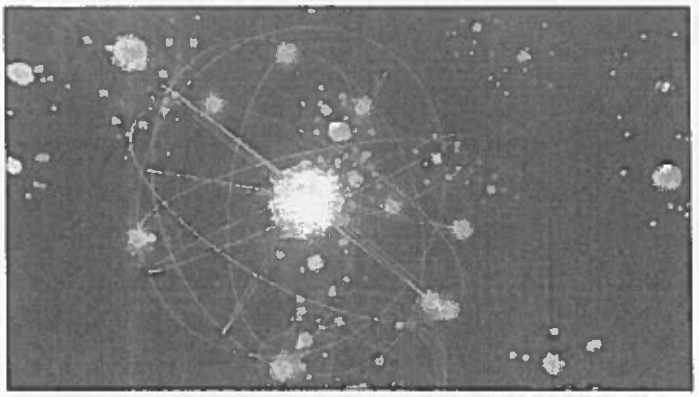
which, once more, clearly shows that only the longitudinal component $l=1$ contributes to the ion density fluctuations. The final form of $\mathcal{H}_{ph}$ in terms of the coordinates $Q_{\kappa l}$ is then

$$\mathcal{H}_{ph} = \sum_\kappa\left\{\frac{1}{2}\sum_l\left[P^\dagger_{\kappa l}P_{\kappa l} + \Omega^2_{\kappa l}\,Q^\dagger_{\kappa l}Q_{\kappa l}\right] + \frac{n_i}{M}\,\kappa^2\, w_\kappa\,\frac{1-\epsilon(\kappa,\omega)}{\epsilon(\kappa,\omega)}\,Q^\dagger_{\kappa l=1}Q_{\kappa l=1}\right\}$$

The eigenvalues of this Hamiltonian must be obtained self-consistently with the frequency ω appearing in the electron-ion coupling. As such a procedure is quite cumbersome, a simple and most reasonable approximation is to assume a negligible frequency dependence for the dielectric function, that is $\epsilon(\kappa,\omega)\simeq\epsilon(\kappa,0)$ which in the limit of $\kappa\to 0$ is given as $\epsilon(\kappa,0)\simeq 1+k_s^2/\kappa^2$. This specific approximation with the screening wave vector k_s deduced from accurate electron gas calculations has been discussed in detail in [89] to compare calculated and experimental long wavelength longitudinal collective mode velocities of a wide set of liquid metals.

The $\mathcal{H}_{ph}$ Hamiltonian provides eigenvalues with a negligible imaginary part as the only contribution to the collective modes damping is due to the imaginary part of the dielectric function, which is very small in this energy limit ($\hbar\omega \ll E_F$). This is rather in disagreement with the experimental findings that show a notable mode damping over the kinematic accessible range. Indeed, an important contribution to the collective mode damping comes from the microscopic intrinsic disorder always present in a liquid system [153]. Moreover, we remark that the Hamiltonian $\mathcal{H}_{ph}$ models a homogeneous and isotropic system, whereas at microscopic level the symmetry is spontaneously broken. To account for such an effect, additional terms have to be introduced in the Hamiltonian of the liquid system. Considering that in a disordered system no ordering of the eigenvalues with the momentum is possible, and that in the long wavelength

4



Electrons (red; illustration) need only 13–34 femtoseconds to excite and redistribute their energy when hit with laser light. Credit: Shutterstock

ATOMIC AND MOLECULAR PHYSICS · 19 FEBRUARY 2021

Electrons are caught in the act of relaxing – over quadrillionths of a second

Physicists fire lasers at electrons to understand how the particles gain and shed energy.

Physicists have observed with record precision how electrons, when excited by light, gain and redistribute energy over time — a phenomenon that previous research has been unable to measure on such short timescales.

In repeated experiments, Daniel Neumark and Stephen Leone at the University of California, Berkeley, and their colleagues hit a 50-nanometre-thick sample of nickel with a visible-light laser to excite the metal's electrons. With a range of delays, the researchers then hit the sample with an extreme-ultraviolet laser pulse less than 4 femtoseconds (four-quadrillionths of a second) long. They measured absorption of this pulse by the sample, which allowed them to infer how collective characteristics of the electrons in nickel changed over time.

The excited electrons reached an equilibrium by redistributing energy among themselves — a process that took 13–34 femtoseconds, depending on the total energy of the initial visible-light pulse. The particles then cooled over a period of around 640 femtoseconds.

The work provides a way for physicists to probe the dynamics of electrons in ultrafast light-induced processes, such as those that take place in solar cells.

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Atomic and molecular physics

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