TOP SECRET ~~TOP SECRET~~ July 3rd 1944.

B4 Niels Bohr

MEMORANDUM.

The project of releasing, to an unprecedented scale, the energy bound in matter is based on the remarkable development of physical science in our century, which has given us the first real insight in the interior structure of the atom.

This development has taught us that each atom consists of a cluster of electrified corpuscles, the so-called electrons, held together by the attraction from a nucleus which, although it contains practically the whole mass of the atom, has a size extremely small compared with the extension of the electron cluster.

By contributions of physicists from nearly every part of the world, the problems of the electron configuration within the atom were in the course of relatively few years most successfully explored and led above all to a clarification of the relationship between the elements as regards their ordinary physical and chemical properties.

In fact all properties of matter, like hardness of materials, electric conductivity and chemical affinities, which through the ages have been exploited for technical developments to an ever increasing extent, are determined only by the electronic configuration and are practically independent of the intrinsic structure of the nucleus.

This simplicity has its root in the circumstance that by exposure of materials to ordinary physical or chemical agencies, any change in the atomic constitution is confined to distortion or disrupture of the electron cluster while the atomic nuclei are left entirely unchanged.

The stability of the nuclei under such conditions is in fact the basis for the doctrine of the immutability of the elements which for so long has been a fundament for physics and chemistry.

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A whole new epoc of science was, therefore, initiated by the discovery that it is possible, by special agencies like the high speed particles emitted by Radium, to produce disintegrations of the atomic nuclei themselves and thereby to transform one element into another.

The closer study of the new phenomena revealed characteristic features which differ most markedly from the properties of matter hitherto known, and above all it was found that nuclear transmutations may be accompanied by an energy release per atom millions of times larger than the energy exchanged in the most violent chemical reactions.

Although at that stage no ways were yet open of releasing for practical purposes the enormous energy stored in the nuclei of atoms, an immediate clue was obtained to the origin of the so far quite unknown energy sources present in the interior of the stars, and in particular it became possible to explain how our sun has been able through billions of years to emit the powerful radiation upon which all organic life on the earth is dependent.

The rapid exploration of this novel field of research, in which international cooperation has again been most fruitful, led within the last decenniums to a number of important discoveries regarding the intrinsic properties of atomic nuclei and especially revealed the existence of a non-electrified nuclear constituent, the so-called neutron, which, when set free, is a particularly active reagens in producing nuclear transmutations.

The actual impetus to the present project was the discovery, made in the last year before the war, that the nuclei of the heaviest elements, like Uranium, by neutron bombardment, in the so-called fission process, may split in fragments ejected with enormous energies, and that this process is accompanied by the release of further neutrons which may themselves effect the splitting of other heavy nuclei.

This discovery indicated for the first time the possibility, through propagation of nuclear disintegrations from atom to atom, to obtain a new kind of combustion of matter with immense energy yield. In fact, a complete nuclear combustion of heavy materials would release

an energy 100.000.000 times larger than that obtainable by [redacted] same amount of chemical explosives.

This prospect not only at once attracted the most wide spread interest among physicists, but of its appeal to the imagination of larger circles I have vivid recollections from my stay in U.S.A. in the spring of 1939 where, as guest of the Institute of Advanced Studies in Princeton, I had the pleasure to participate together with American colleagues in investigations on the mechanism of the fission process.

Such investigations revealed that among the substances present in natural ores, only a certain modification of Uranium fulfils the conditions for nuclear combustion. Since this active substance always occurs mixed with a more abundant, inactive Uranium modification, it was, therefore, realized that in order to produce devastating explosives, it would be necessary to subject the available materials to a treatment of an extremely refined and elaborate character.

The recognition that the accomplishment of the project would thus require an immense technical effort, which might even prove impracticable, was at that time, not least in view of the imminent threat of military aggression, considered as a great comfort since it would surely prevent any nation from staging a surprise attack with such super weapons.

Any progress on nuclear problems achieved before the war was, of course, common knowledge to physicists all over the world, but after the outbreak of hostilities no further information has been made public, and efforts to exploit nuclear energy sources have been kept as military secrets.

During my stay in Denmark under the German occupation nothing was, therefore, known to me about the great enterprise in America and England. It was, however, possible, due to connections originating from regular visits of German physicists to the Institute for Theoretical Physics in Copenhagen in the years between the wars, rather closely to follow the work on such lines which from the very beginning of the war was organized by the German Government.

[redacted]

Although thorough preparations were made by a most energetic scientific effort, disposing of expert knowledge and considerable material resources, it appeared from all information available to us, that at any rate in the initial for Germany so favourable stages of the war it was never by the Government deemed worth while to attempt the immense and hazardous technical enterprise which an accomplishment of the project would require.

Immediately after my escape to Sweden in October 1943, I came on an invitation of the British Government to England where I was taken into confidence about the great progress achieved in America and went shortly afterwards together with a number of British colleagues to U.S.A. to take part in the work. In order, however, to conceal my connection with any such enterprise, post-war planning of international scientific cooperation was given as the object of my journey.

Already in Denmark I had been in secret connection with the British Intelligence Service, and more recently I have had the opportunity with American and British Intelligence Officers to discuss the latest information, pointing to a feverish German activity on nuclear problems. In this connect on it must above all be realized that if any knowledge of the progress of the work in American should have reached Germany, it may have caused the Government to reconsider the possibilities and will not least have presented the physicists and technical experts with an extreme challenge.

Definite information of preparations elsewhere is hardly available, but an interest within the Soviet Union for the project may perhaps be indicated by a letter which I have received froma prominent Russian physicist with whom I had formed a personal friendship during hismany years' stay in England and whom I visited in Moscow a few years before the war, to take part in scientific conferences.

This letter contained an official invitation to come to Moscow to join in scientific work with Russian colleagues who, as I was told, in the initial stages of the war were fully occupied with technical problems of immediate importance for the defence of their country, but now had the opportunity to devote themselves to scientific research of more

general character. No reference was made to any special subject but from pre-war work of Russian physicists it is natural to assume that nuclear problems will be in the center of interest.

The letter, originally sent to Sweden in October 1943, was on my recent visit to London handed to me by the Counsellor of the Soviet Embassy who in a most encouraging manner stressed the promises for the future understanding between nations entailed in scientific collaboration. Although, of course, the project was not mentioned in this conversation I got nevertheless the impression that the Soviet Officials were very interested in the effort in America, about the success of which some rumours may have reached the Soviet Union.

Even if every physicist was prepared that some day the prospects created by modern researches would materialize, it was a revelation to me to learn about the courage and foresight with which the great American and British enterprise had been undertaken and about the advanced stage the work had already reached.

What until a few years ago might have been considered a fantastic dream is at the moment being realized in great laboratories erected for secrecy in some of the most solitary regions of the States. There a group of physicists larger than ever before assembled for a single purpose, and working hand in hand with a whole army of engineers and technicians are producing new materials capable of enormous energy release and developing ingenious devices for their most effective use.

To everyone who is given the opportunity for himself to see the refined laboratory equipment and the huge production machinery, it is an unforgettable experience of which words can only give a poor impression. Truly, no effort has been spared and it is hardly possible for me to describe my admiration for the efficiency with which the great work has been planned and conducted.

Moreover, it was a special pleasure to me to witness the complete harmony with which the American and British physicists, with almost everyone of whom I was intimately acquainted through previous scientific intercourse, were devoting themselves with the utmost zeal to the joint effort.

I shall not here enter on technical details, but one cannot help comparing with the Alchemysts of former days, groping in the dark in their vain efforts to make gold. Today physicists and engineers are on the basis of well established knowledge directing and controlling processes by which substances far more precious than gold are being collected atom by atom or even built up by individual nuclear transmutations.

Such substances must be assumed to have been abundant in the early stages of our universe where all matter was subject to conditions far more violent than those which still persist in the turbulent and flaming interior of the stars. Due, however, to their inherent instability the active materials now extracted or produced have in the course of time become very rare or even completely disappeared from the household of nature.

The whole enterprise constitutes indeed a far deeper interference with the natural course of events than anything ever before attempted and its impending accomplishment will bring about a whole new situation as regards human resources. Surely, we are being presented with one of the greatest triumphs of science and engineering destined deeply to influence the future of mankind.

It certainly surpasses the imagination of anyone to survey the consequences of the project in years to come, where in the long run the enormous energy sources which will be available may be expected to revolutionize industry and transport. The fact of immediate preponderance is, however, that a weapon of an unparallelled power is being created which will completely change all future conditions of warfare.

Quite apart from the questions of how soon the weapon will be ready for use and what role it may play in the present war,

this situation raises a number of problems which call for most urgent attention. Unless, indeed, some agreement about the control of the use of the new active materials can be obtained in due time, any temporary advantage, however great, may be outweighed by a perpetual menace to human security.

Ever since the possibilities of releasing atomic energy on a vast scale came in sight, much thought has naturally been given to the question of control, but the further the exploration of the scientific problems concerned is proceeding the clearer it becomes that no kind of customary measures will suffice for this purpose and that especially the terrifying prospects of a future competition between nations about a weapon of such formidable character can only be avoided through a universal agreement in true confidence.

In this connection it is above all significant that the enterprise, immense as it is, has still proved far smaller than might have been anticipated and that the progress of the work has continually revealed new possibilities for facilitating the production of the active materials and of intensifying their effects.

The prevention of a competition prepared in secrecy will, therefore, demand such concessions regarding exchange of information and openness about industrial efforts including military preparations as would hardly be conceivable unless at the same time all partners were assured of a compensating guarantee of common security against dangers of unprecedented acuteness.

The establishment of effective control measures will, of course, involve intricate technical and administrative problems, but the main point of the argument is that the accomplishment of the project would not only seem to necessitate but should also, due to the urgency of mutual confidence, facilitate a new approach to the problem of international relationship.

The present moment where almost all nations are entangled in a deadly struggle for freedom and humanity might at first sight seem most unsuited for any committing arrangement concerning the project. Not only have the aggressive powers still great military

strength, although their original plans of world domination have been frustrated and it seems certain that they must ultimately surrender, but even when this happens, the nations united against aggression may face grave causes of disagreement due to conflicting attitudes towards social and economic problems.

By a closer consideration, however, it would appear that the potentialities of the project as a means of inspiring confidence just under these circumstances acquire most actual importance. Moreover, the momentary situation would in various respects seem to afford quite unique possibilities which might be forfeited by a postponement awaiting the further development of the war situation and the final completion of the new weapon.

Although there can hardly be any doubt that the American and British enterprise is at a more advanced stage than any similar undertaking elsewhere, one must be prepared that a competition in the near future may become a serious reality. In fact, as already indicated, it seems likely that preparations, possibly urged on by rumours about the progress in America, are being speeded up in Germany and may even by under way in the Soviet Union.

Further it must be realized that the final defeat of Germany will not only release immense resources for a full scale effort within the Soviet Union, but will presumably also place all scientific knowledge and technical experience collected in Germany at the disposal for such an effort.

In view of these eventualities the present situation would seem to offer a most favourable opportunity for an early initiative from the side which by good fortune has achieved a lead in the efforts of mastering mighty forces of nature hitherto beyond human reach.

Without impeding the importance of the project for immediate military objectives, an initiative, aiming at forestalling a fateful competition about the formidable weapon, should serve to uproot any cause of distrust between the powers on whose harmonious collaboration the fate of coming generations will depend.

Indeed, it would appear that only when the question is taken up among the United Nations of what concessions the various powers are prepared to make as their contribution to an adequate control

arrangement, it will be possible for anyone of the partners to assure themselves of the sincerity of the intentions of the others.

Of course, the responsible statesmen alone can have the insight in the actual political possibilities. It would, however, seem most fortunate that the expectations for a future harmonious international cooperation which have found unanimous expression from all sides within the United Nations, so remarkably correspond to the unique opportunities which, unknown to the public, have been created by the advancement of science.

Many reasons, indeed, would seem to justify the conviction that an approach with the object of establishing common security from ominous menaces without excluding any nation from participating in the promising industrial development which the accomplishment of the project entails will be welcomed, and be responded with a loyal co-operation on the enforcement of the necessary far reaching control measures.

Just in such respects helpful support may perhaps be afforded by the world wide scientific collaboration which for years has embodied such bright promises for common human striving. On this background personal connections between scientists of different nations might even offer means of establishing preliminary and non-committal contact.

It need hardly be added that any such remark or suggestion implies no underrating of the difficulty and delicasy of the steps to be taken by the statemmen in order to obtain an arrangement satisfactory to all concerned, but aims only at pointing to some aspects of the situation which might facilitate endeavours to turn the project to lasting benefit for the common cause.